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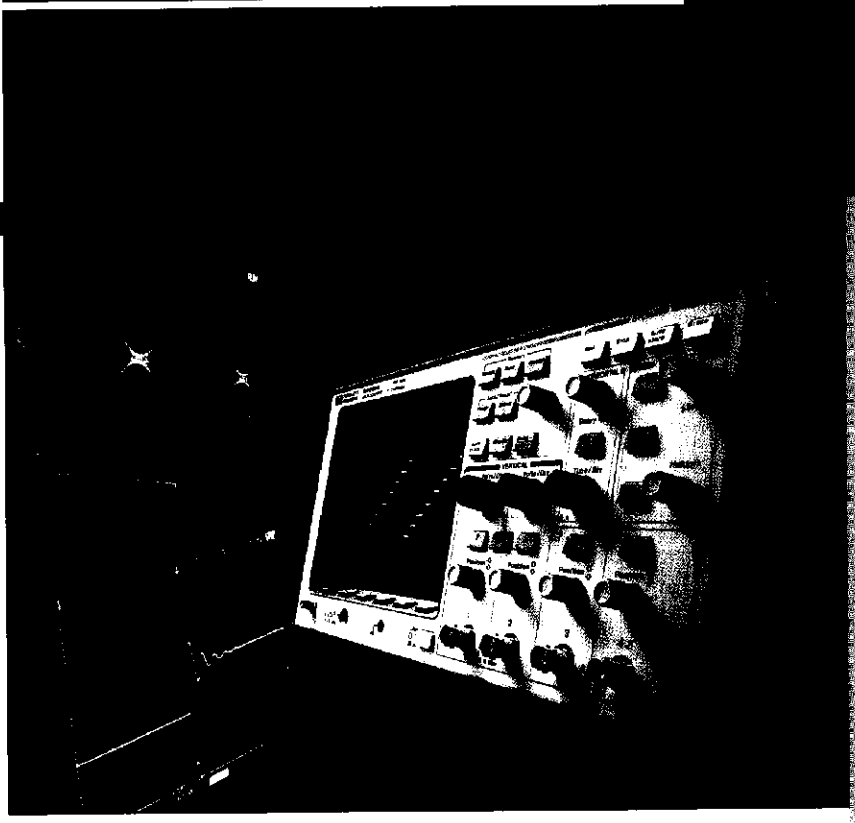

User and Service Guide

HP 54600-Series Oscilloscopes

User and Service Guide

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HP 54600-Series Oscilloscopes

General-Purpose Oscilloscopes

The HP 54600-Series Oscilloscopes offer exceptional waveform viewing and measurements in a small, lightweight package. The two-channel HP 54600A is suited for production, field service, and education applications. The four-channel HP 54601A is best suited for research and design labs, and applications involving digital circuit test and troubleshooting. For higher frequency applications, the HP 54602A provides 150 MHz bandwidth and triggering up to 250 MHz. Each of these oscilloscopes gives you:

- 100-MHz bandwidth, 2 ns/div main and delayed time bases
- Automatic setup of the front panel
- Automatic and cursor measurements of frequency, time, and voltage
- Waveform storage
- Save and recall of 16 front-panel setups
- Peak detect

These oscilloscopes are easy to use with familiar controls and high display update rate, but with none of the viewing problems that are associated with analog oscilloscopes. A bright, crisp display is obtained at all sweep speeds and delayed sweep magnifications. Storage is as simple as pressing a button. Negative time allows the viewing of events that occur before the trigger event. Cursors and automatic measurements greatly simplify the analysis of these events. You can upgrade both of the oscilloscopes to print to a printer or to plot to a plotter, or remote control by either HP-IB or RS-232. The HP 54653A ScopeLink software simplifies the transfer of waveforms, data, and setups to a personal computer for analysis and documentation.

Accessories supplied

- Two 1.5 meter, 10:1 Probes (HP 10071A)
- Power cord for country of destination
- This *User and Service Guide*

Accessories available

- HP 54650A HP-IB Interface Module
- HP 54651A RS-232 Interface Module
- HP 54652A Parallel Interface Module
- HP 54653A ScopeLink Software
- HP 54654A Operator's Training Kit
- HP 54655A and HP 54656A Test Automation Modules
- HP 54657A and HP 54678A Measurement/Storage Modules
- HP 5041-9409 Carrying Case
- HP 5062-7345 Rackmount Kit
- HP 10079A Camera
- HP 10070A 1.5 meter, 1:1 Probe
- HP 10100C 50 Ω Termination

Options available

- Option 001 RS-03 Magnetic Interference Shielding Added to CRT
- Option 002 RE-02 Display Shield Added to CRT
- Option 101 Accessory Pouch and Front-Panel Cover
- Option 102 Two Additional 10:1 Probes (HP 10071A)
- Option 103 Operator's Training Kit (HP 54654A)
- Option 104 Carrying Case (HP 5041-9409)
- Option 105 ScopeLink Software (HP 54653A)
- Option 090 Deletes Probe
- Option 908 Rackmount Kit (HP 5062-7345)
- Power Cords (see "Replaceable Parts," table 15 on page 115)

In This Book

This book is the operating and service manual for the HP 54600-Series Oscilloscopes, and contains four chapters.

Beginners Chapter 1 is a quick start guide that gives you a brief overview of the oscilloscope.

Advanced users Chapter 2 is a series of exercises that guide you through the operation of the oscilloscope.

Service technicians Chapter 3 contains the service information for the oscilloscope. There are procedures for verifying performance, adjusting, troubleshooting, and replacing assemblies in the oscilloscope

Reference information Chapter 4 lists the characteristics of the oscilloscope.

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1

The Oscilloscope at a Glance

The Oscilloscope at a Glance

One of the first things you will want to do with your new oscilloscope is to become acquainted with its front panel. Therefore, we have written the exercises in this chapter to familiarize you with some of its controls.

The front panel has knobs, grey keys, and white keys. The knobs are used most often and are similar to the knobs on other oscilloscopes. The grey keys bring up softkey menus on the display that allow you access to many of the oscilloscope features. The white keys are instant action keys and menus are not associated with them.

Throughout this book, the front-panel keys are denoted by a box around the name of the key, and softkeys are denoted by a change in the text type. For example, [Source] is the grey front-panel key labeled source under the trigger portion of the front panel, and **Line** is a softkey. The word **Line** is at the bottom of the display directly above an unlabeled softkey (which is also grey).

The rear cover of this book is a fold out reference guide. On this cover you will find a diagram of the front panel, and inside the cover is another diagram showing which grey keys to press to bring up the softkey menus.

The status line, located at the top of of the display, lets you quickly determine the setup of the oscilloscope. In this chapter you will learn to interpret the setup of the oscilloscope from the status line. An example of the status line is on the rear cover of this book.

To connect a signal to the oscilloscope

The HP 54600A is a two-channel oscilloscope with an external trigger input, while the HP 54601A and HP 54602A are four-channel oscilloscopes. The four-channel oscilloscope replaces the external trigger input with channels 3 and 4. In this exercise you connect a signal to the channel 1 input.

To avoid damage to your new oscilloscope, make sure that the voltage level of the signal you are using is less than or equal to 400 V (dc plus the peak ac). For a complete list of the characteristics see chapter 4, "Performance Characteristics," on page 117.

- Use a cable or a probe to connect a signal to channel 1.

  If you are using a probe, the oscilloscope allows you to enter the attenuation factor for the probe. The attenuation factor changes the vertical scaling of the oscilloscope so that the measurement results reflect the actual voltage levels at the probe tip.

- To set the probe attenuation factor press [1]. Next toggle the **Probe** softkey to change the attenuation factor to match the probe you are using.

To connect a signal to the oscilloscope

You should compensate 10:1 probes to match their characteristics to the oscilloscope. A poorly compensated probe can introduce measurement errors. To compensate a probe, follow these steps

1. Connect the 10:1 probe from channel 1 to the front-panel probe adjust signal on the oscilloscope.
2. Press [Autoscale].
3. Use a nonmetallic tool to adjust the trimmer capacitor on the probe for the flattest pulse possible as displayed on the oscilloscope.

Figure 1

Overcompensation causes pulse peaking

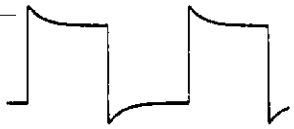


Figure 2

Correct compensation with a flat pulse top.

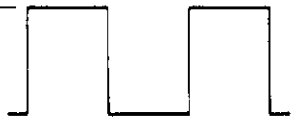


Figure 3

Undercompensation causes pulse rolloff

To display a signal automatically

The oscilloscope has an Autoscale feature that automatically sets up the oscilloscope to best display the input signal. Using Autoscale requires signals with a frequency greater than or equal to 50 Hz and a duty cycle greater than 1%

When you press the Autoscale key, the oscilloscope turns on and scales all channels that have signals applied, and it selects a time base range based on the trigger source. The trigger source selected is the highest numbered input that has a signal applied. (If a signal is connected to the external trigger input on the HP 54600A, then it is selected as the trigger source.)

1 Connect a signal to the oscilloscope.

2 Press [Autoscale].

When you press the Autoscale key, the oscilloscope changes the front-panel setup to display the signal. However, if you pressed the Autoscale key unintentionally, you can use the Undo Autoscale feature. To use this feature, perform the following step

- Press [Setup]. Next, press the **Undo Autoscale** softkey.

  The oscilloscope returns to the configuration in effect before you pressed the Autoscale key.

To set up the vertical window

The following exercise guides you through the vertical keys, knobs, and status line.

1 Center the signal on the display with the Position knob.

The Position knob moves the signal vertically, and it is calibrated. Notice that as you turn the Position knob, a voltage value is displayed for a short time indicating how far the ground reference is located from the center of the screen. Also notice that the ground symbol on the right side of the display moves in conjunction with the Position knob

Measurement hints

If the channel is dc coupled, you can quickly measure the dc component of the signal by simply noting its distance from the ground symbol.

If the channel is ac coupled, the dc component of the signal is removed allowing you to use greater sensitivity to display the ac component of the signal.

2 Change the vertical setup and notice that each change affects the status line differently.

You can quickly determine the vertical setup from the status line in the display

- Change the vertical sensitivity with the Volts/Div knob and notice that it causes the status line to change. For channels 3 and 4 on the HP 54601A and HP 54602A, press [3] or [4]. Then use the softkeys to change the vertical sensitivity.
- Press [1].

  A softkey menu appears on the display, and the channel turns on (or remains on if it was already turned on).
- Toggle each of the softkeys and notice which keys cause the status line to change.

  Channels 1 and 2 have a vernier softkey that allows the Volt/Div knob to change the vertical step size in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on
- To turn the channel off, either press [1] a second time or press the left-most softkey.

Invert operating hint

When you are triggered on the signal you are inverting, the inversion also applies to the trigger signal (what was a rising edge now is a falling edge). If the signal has a 50% duty cycle (square wave or sine wave), the displayed waveform appears not to invert. However, for signals with a duty cycle other than 50%, the displayed waveform does invert as you would expect.

To set up the time base

The following exercise guides you through the time base keys, knobs, and status line

1 Turn the Time/Div knob and notice the change it makes to the status line.

The Time/Div knob changes the sweep speed from 2 ns to 5 s in a 1-2-5 step sequence, and the value is displayed in the status line.

2 Change the horizontal setup and notice that each change affects the status line differently.

- Press `Main/Delayed`.

  A softkey menu appears on the display with six softkey choices.

- Toggle each of the softkeys and notice which keys cause the status line to change.

There is also a horizontal vernier softkey that allows the Time/Div knob to change the sweep speed in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on.

- Turn the Delay knob and notice that its value is displayed in the status line.

  The Delay knob moves the main sweep horizontally, and it pauses at 0.00 s, mimicking a mechanical detent. At the top of the graticule is a solid triangle (▼) symbol and an open triangle (∇) symbol. The ▼ symbol indicates the trigger point and it moves in conjunction with the Delay knob. The ∇ symbol indicates the time reference point. If the time reference softkey is set to left, the ∇ is located one graticule in from the left side of the display. If the time reference softkey is set to center, the ∇ is located at the center of the display. The delay number tells you how far the reference point ∇ is located from the trigger point ▼.

  All events displayed left of the trigger point ▼ happened before the trigger occurred, and these events are called pretrigger information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point ▼ is called posttrigger information. The amount of delay range (pretrigger and posttrigger information) available is dependent on the sweep speed selected. See "Horizontal System," on page 120.

To trigger the oscilloscope

The following exercise guides you through the trigger keys, knobs, and status line

1 **Turn the trigger Level knob and notice the changes it makes to the display.**

On the HP 54601A and HP 54602A and on an internally triggered HP 54600A, as you turn the Level knob or press a trigger menu key, for a short time two things happen on the display. First, the trigger level is displayed in inverse video. If the trigger is dc coupled, it is displayed as a voltage. If the trigger is ac coupled or if LF reject was selected, it is displayed as a percentage of the trigger range. Second, if the trigger source is turned on, a line is displayed showing the location of the trigger level (as long as ac coupling or low frequency reject are not selected).

2 **Change the trigger setup and notice that each change affects the status line differently.**

- Press [Source]

  A softkey menu appears on the display showing the trigger source choices

- Toggle each of the softkeys and notice that each key causes the status line to change

- Press Mode .
  A softkey menu appears on the display with five trigger mode choices.
- Toggle the **Single** and **TV** softkeys and notice that they affect the status line differently. (You can only select TV if the trigger source is either channel 1 or 2.)
  When the oscilloscope is triggering properly, the trigger mode portion of the status line is blank.

What happens if the oscilloscope loses trigger?

If Auto Level is the trigger mode, Auto flashes in the status line. If dc coupled, the oscilloscope resets the trigger level to the center of the signal. If ac coupled, the oscilloscope resets the trigger level to the middle of the screen. (Every time you press the Auto Level softkey, the oscilloscope resets the trigger level.)

If Auto is the trigger mode, Auto flashes in the status line and the oscilloscope free runs.

If either Normal or TV is the trigger mode, the trigger setup flashes in the status line.

- Press `Slope/Coupling`

  A softkey menu appears on the display. If you selected Auto level, Auto, Normal, or Single as a trigger mode, six softkey choices are displayed. If you selected TV as a trigger source, five other softkey choices are available.

- Toggle each of the softkeys and notice which keys affect the status line.

  On the HP 54600A, external trigger is always dc coupled. If you select ac coupling or low frequency reject, these functions do not occur until you change the trigger source to channel 1, channel 2, or line.

3 Adjust the Holdoff knob and notice the change it makes to the display.

Holdoff keeps the trigger from rearming for an amount of time that you set with the Holdoff knob. Holdoff is often used to stabilize the complex waveforms. The Holdoff range is from 200.0 ns to about 13.5 s. It is displayed, for a short time, in inverse video near the bottom of the display.

To use roll mode

Roll mode continuously moves data across the display from right to left. It allows you to see dynamic changes (like adjusting a potentiometer) on low frequency signals. Two frequently used applications are transducer monitoring and power supply testing.

1 Press [Mode]. Then press the **Auto Lvl**, **Auto**, or **Normal** softkey.

2 Press [Main/Delayed].

3 Press the **Roll** softkey.

The oscilloscope is now untriggered and runs continuously. Also notice that the time reference softkey selection changes to center and right.

4 Press [Mode]. Then press the **Single** softkey.

The oscilloscope fills either $\frac{1}{2}$ or $\frac{9}{10}$ of the display (depending on the time reference selection), then it searches for a trigger. After a trigger is found, the remainder of the display is filled. Then, the oscilloscope stops acquiring data.

You can also make automatic measurements in the roll mode. Notice that the oscilloscope briefly interrupts the moving data while it makes the measurement. The acquisition system does not miss any data during the measurement. The slight shift in the display after the measurement is complete is that of the display catching up to the acquisition system.

Roll mode operating hints

Roll mode operates on channels 1 and 2 only.
Math functions, averaging, and peak detect are not available.
Holdoff and horizontal delay do not affect the signal.
Both a free running (nontriggered) display and a triggered display (available in the single mode only) are available.
It is available at sweep speeds up to 200 ms.

2

Operating Your Oscilloscope

Operating Your Oscilloscope

By now you are familiar with the VERTICAL, HORIZONTAL, and TRIGGER groups of the front-panel keys. You should also know how to determine the setup of the oscilloscope by looking at the status line. If you are unfamiliar with this information, we recommend you read chapter 1, "The Oscilloscope at a Glance," starting on page 7.

This chapter takes you through two new groups of front-panel keys: STORAGE, and the group of keys that contains the Measure, Save/Recall, and Display keys. You will also add to your knowledge of the HORIZONTAL keys by using delayed sweep.

We recommend you perform all of the following exercises so you become familiar with the powerful measurement capabilities of the oscilloscope.

To use delayed sweep

Delayed sweep is a magnified portion of the main sweep. You can use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (high resolution) analysis of signals. The following steps show you how to use delayed sweep. Notice that the steps are very similar to operating the delayed sweep in analog oscilloscopes.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press `Main/Delayed`.

3 Press the **Delayed** softkey.

The screen divides in half. The top half displays the main sweep, and the bottom half displays an expanded portion of the main sweep. This expanded portion of the main sweep is called the delayed sweep. The top half also has two solid vertical lines called markers. These markers show what portion of the main sweep is expanded in the lower half. The size and position of the delayed sweep are controlled by the Time/Div and Delay knobs. The Time/Div next to the symbol is the delayed sweep sec/div. The delay value is displayed for a short time at the bottom of the display.

- To display the delay value of the delayed time base, either press `Main/Delayed` or turn the Delay knob.
- To change the main sweep Time/Div, you must turn off the delayed sweep

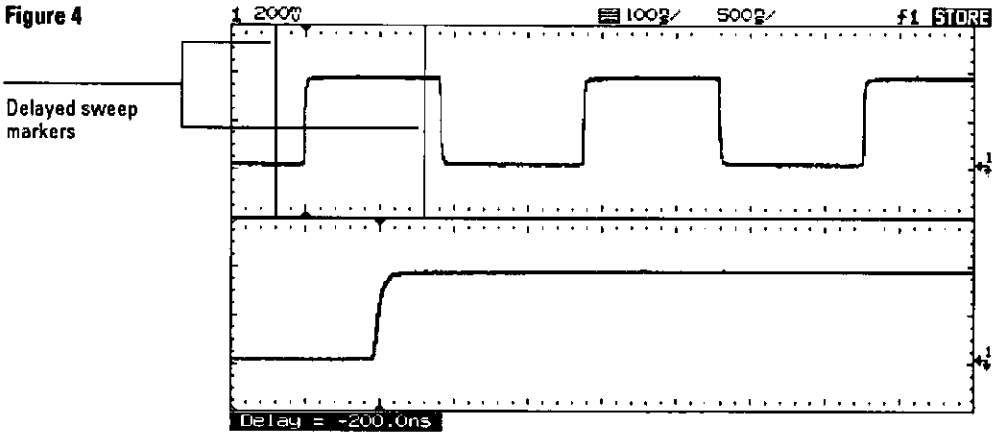
Since both the main and delayed sweeps are displayed, there are half as many vertical divisions so the vertical scaling is doubled Notice the changes in the status line.

- To display the delay time of the delayed sweep, either press `Main/Delayed` or turn the delay knob The delay value is displayed near the bottom of the display.

4 Set the **`time reference`** to either **`left`** or **`center`**.

Figure 4 shows the time reference set to left. The operation is like the delayed sweep of an analog oscilloscope, where the delay time defines the start of the delayed sweep.

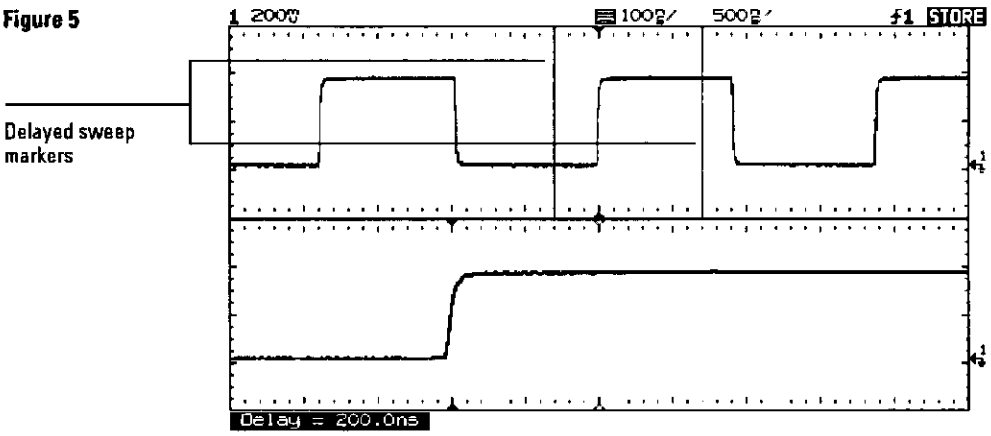
Figure 4



Time reference set to left

Figure 5 shows the time reference set to center. Notice that the markers expand around the area of interest. You can place the markers over the area of interest with the delay knob, then expand the delayed sweep with the time base knob to increase the resolution.

Figure 5



Time reference set to center

To use storage oscilloscope operation

There are four front-panel storage keys. They are white instant action keys that change the operating mode of the oscilloscope The following steps demonstrate how to use these storage keys.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press Autostore .

Notice that STORE replaces RUN in the status line.

For easy viewing, the stored waveform is displayed in half bright and the most recent trace is displayed in full bright. Autostore is useful in a number of applications

- Displaying the worst-case extremes of varying waveforms
- Capturing and storing a waveform
- Measuring noise and jitter
- Capturing events that occur infrequently

3 Using the position knob, move the trace up and down about one division.

Notice that the last acquired waveform is in full bright and the previously acquired waveforms are displayed in half bright.

- To characterize the waveforms, use the cursors. See "To make cursor measurements" on page 43.
- To clear the display, press Erase.
- To exit the Autostore mode, press either Run or Autostore.

Summary of storage keys

Run – The oscilloscope acquires data and displays the most recent trace.

Stop – The display is frozen.

Autostore – The oscilloscope acquires data, displaying the most recent trace in full bright and previously acquired waveforms in half bright.

Erase – Clears the display.

To capture a single event

To capture a single event, you need some previous knowledge of the signal in order to set up the trigger level and slope. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge. The following steps show you how to use the oscilloscope to capture a single event.

1 Connect a signal to the oscilloscope.

2 Set up the trigger.

- Press [Source]. Select a trigger source with the softkeys
- Press [Slope/Coupling]. Select a trigger slope with the softkeys.
- Turn the Level knob to a point where you think the trigger should work.

3 Press [Mode], then press the **Single** softkey.

4 Press [Erase] to clear previous measurements from the display.

5 Press [Run].

Pressing the Run key arms the trigger circuit. When the trigger conditions are met, data appears on the display representing the data points that the oscilloscope obtained with one acquisition. Pressing the Run key again rearms the trigger circuit and erases the display.

6 If you need to compare several single-shot events, press [Autostore].

Like the Run key, the Autostore key also arms the trigger circuit. When the trigger conditions are met, the oscilloscope triggers. Pressing the Autostore key again rearms the trigger circuit, but this time the display is not erased. All the data points are retained on the display in half bright with each trigger allowing you to easily compare a series of single-shot events

After you have acquired a single-shot event, pressing a front-panel key, softkey, or changing a knob can erase the event from the display. If you press the Stop key, the oscilloscope will recover the event and restore the oscilloscope settings.

- To clear the display, press [Erase].
- To exit the Autostore mode, press either [Run] or [Autostore] Notice that RUN replaces STORE in the status line, indicating that the oscilloscope has exited the Autostore mode.

Operating hint

The single-shot bandwidth is 2 MHz for single-channel operation, and 1 MHz for two-channel operation. There are twice as many sample points per waveform on the one-channel acquisition than on the two-channel acquisition. On the HP 54600A, channels 1 and 2 are captured simultaneously. On the HP 54601A and HP 54602A channels 1 and 2 are captured simultaneously, then on the next trigger channels 3 and 4 are captured simultaneously.

To capture glitches or narrow pulses

A glitch is a rapid change in the waveform that is usually narrow as compared to the waveform. This oscilloscope has two modes of operation that you can use for glitch capture peak detect and Autostore

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Find the glitch.

Use peak detect for narrow pulses or glitches that require sweep speeds slower than 50 μs/div.

- To select peak detect, press Display. Next, press the **Peak Det** softkey.

  Peak detect operates at sweep speeds from 5 s/div to 50 μs/div. When operating, the initials Pk are displayed in the status line in inverse video. At sweep speeds faster than 50 μs/div, the Pk initials are not displayed in inverse video, which indicates that peak detect is not operating.

Use Autostore for the following cases: waveforms that are changing, waveforms that you want to view and compare with stored waveforms, and narrow pulses or glitches that occur infrequently but require the use of sweep speeds outside the range of peak detect.

- Press [Autostore].

  You can use peak detect and Autostore together. Peak detect captures the glitch, while Autostore retains the glitch on the display in half bright video.

3 Characterize the glitch with delayed sweep.

Peak detect functions in the main sweep only, not in the delayed sweep. To characterize the glitch with delayed sweep follow these steps.

- Press [Main/Delayed]. Next press the **Delayed** softkey.
- To obtain a better resolution of the glitch, expand the time base.
- To set the expanded portion of the main sweep over the glitch, use the Delay knob.
- To characterize the glitch, use the cursors or the automatic measurement capabilities of the oscilloscope.

To trigger on a complex waveform

The difficulty in viewing a complex waveform is triggering on the signal. Figure 6 shows a complex waveform that is not synchronized with the trigger.

The simplest trigger method is to trigger the oscilloscope on a sync pulse that is associated with the waveform. See "To trigger the oscilloscope" on page 16 If there is no sync pulse, use the following procedure to trigger on a periodic complex waveform.

1 Connect a signal to the oscilloscope.

2 Set the trigger level to the middle of the waveform.

3 Adjust the Holdoff knob to synchronize the trigger of the oscilloscope with the complex waveform.

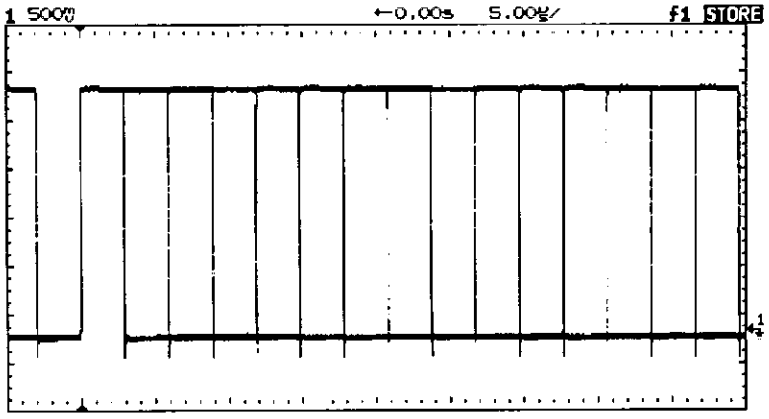
By setting the Holdoff to synchronize the trigger, the oscilloscope ignores the trigger that results in figure 6, and waits for the trigger that results in figure 7. Also notice in figure 6 that the trigger is stable, but the waveform is not synchronized with the trigger

Holdoff operating hints

1 The advantage of digital holdoff is that it is a fixed number. As a result, changing the time base settings does not affect the holdoff number; so, the oscilloscope remains triggered. In contrast, the holdoff in analog oscilloscopes is a function of the time base setting making it necessary to readjust the holdoff each time you change the time base setting.

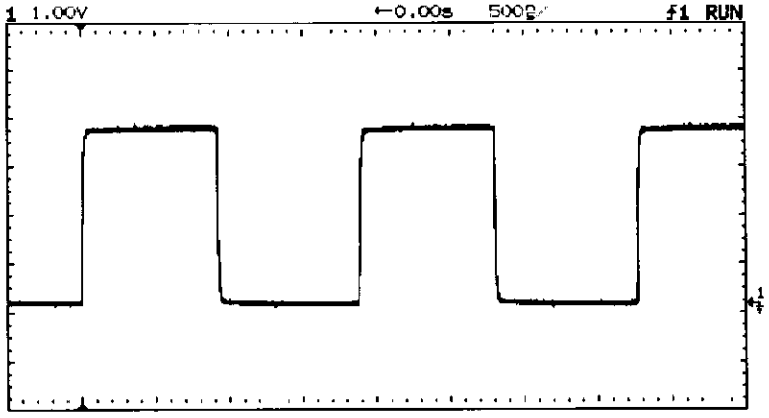
2 The rate of change of the holdoff adjustment knob depends on the time base setting you have selected. If you need a lengthy holdoff setting, increase the time/div setting on the time base, then make your coarse holdoff adjustment. Now switch back to the original time/div setting and make the fine adjustment to reach the exact amount you want.

Figure 6



Stable trigger, but the waveform is not synchronized with the trigger

Figure 7



Holdoff synchronizes the waveform with the trigger

To make frequency measurements automatically

The automatic measurement capability of the oscilloscope makes frequency measurements easy, as the following steps demonstrate

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press [Time].

A softkey menu appears with six softkey choices.

3 Toggle the **Source** softkey to select a channel for the frequency measurement.

4 Press the **Freq** softkey.

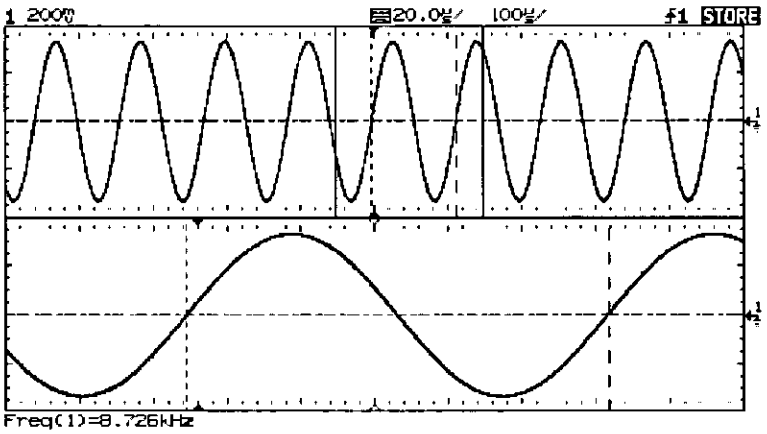
The oscilloscope automatically measures the frequency and displays the result on the lower line of the display. The number in parentheses after the word **Freq** is the number of the channel that the oscilloscope used for the measurement. The oscilloscope retains in memory and displays the three most current measurement results. If you make a fourth measurement, the left-most result is dropped

If the **Show Meas** softkey is turned on, cursors are displayed on the waveform that show the measurement points for the right-most measurement result. If you select more than one measurement, you can show a previous measurement by reselecting the measurement.

- To find the **Show Meas** softkey, press the **Next Menu** softkey key.

The oscilloscope makes automatic measurements on the first displayed event. Figure 8 shows how to use delayed sweep to isolate an event for a frequency measurement. If the measurement is not possible in the delayed time base mode, then the main time base is used. If the waveform is clipped, it may not be possible to make the measurement.

Figure 8



Delayed time base isolates an event for a frequency measurement

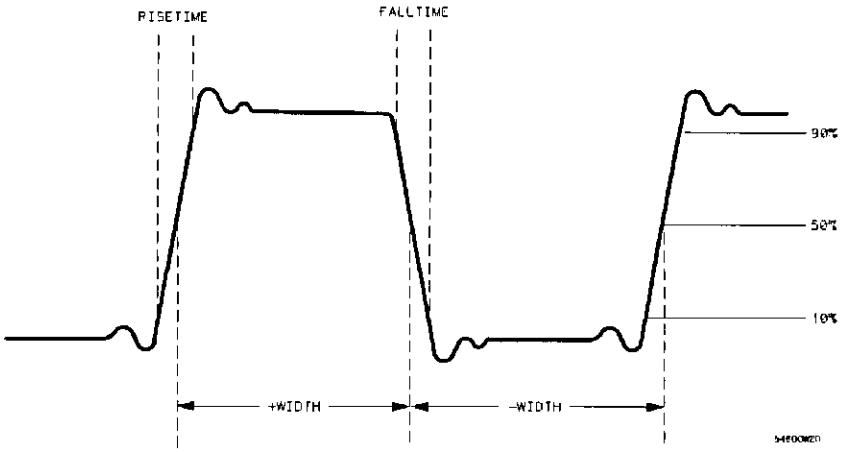
To make time measurements automatically

You can measure the following time parameters with the oscilloscope: frequency, period, duty cycle, width, rise time, and fall time. The following exercise guides you through the Time keys by making a rise time measurement. Figure 9 shows a pulse with some of the time measurement points.

1 Connect a signal to the oscilloscope and obtain a stable display.

When the signal has a well-defined top and bottom, the rise time and fall time measurements are made at the 10% and 90% levels. If the oscilloscope cannot find a well-defined top or bottom, the maximum and minimum levels are used to calculate the 10% and 90% points from. These levels are shown on page 39 in figures 11 and 12.

Figure 9



2 Press [Time].

A softkey menu appears with six softkey choices. Three of the softkeys are time measurement functions

Source Selects a channel for the time measurement.

Time Measurements Three time measurement choices are available: Freq (frequency), Period, and Duty Cy (duty cycle). These measurements are made at the 50% levels. Refer to figure 9.

Clear Meas (clear measurement) Erases the measurement results and removes the cursors from the display.

Next Menu Replaces the softkey menu with six additional softkey choices.

3 Press the **Next Menu** softkey.

Another time measurement softkey menu appears with six additional choices. Four of the softkeys are time measurement functions.

Show Meas (show measurement) Displays the horizontal and vertical cursors where the measurement was taken.

`Time Measurements` Four additional time measurement choices are available; +Width, [Width]−Width, Rise time, and Fall time. Width measurements are made at the 50% levels, whereas rise time and fall time measurements are made at the 10% to 90% levels.

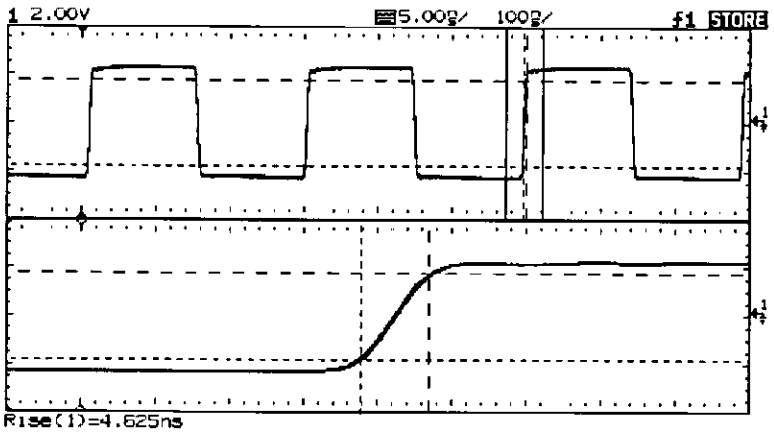
`Previous Menu` Returns to the previous softkey menu.

4 Press the **`Rise Time`** softkey.

The oscilloscope automatically measures the rise time of the signal and displays the result on the display.

The oscilloscope makes automatic measurements on the first displayed event. Figure 10 shows how to use delayed sweep to isolate an edge for a rise time measurement.

Figure 10

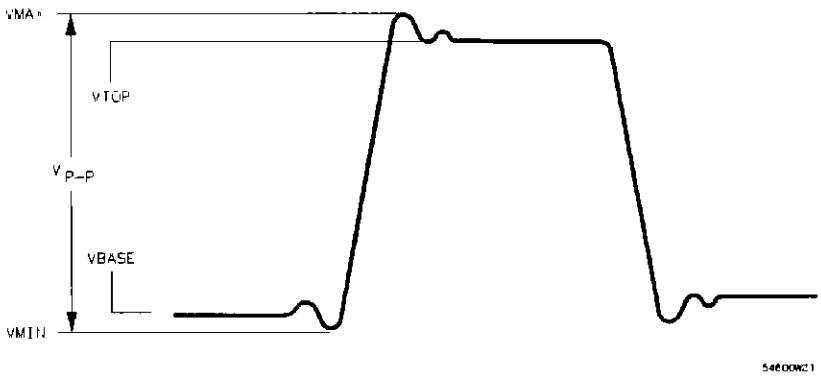


Delayed sweep isolates a leading edge for a rise time measurement

To make voltage measurements automatically

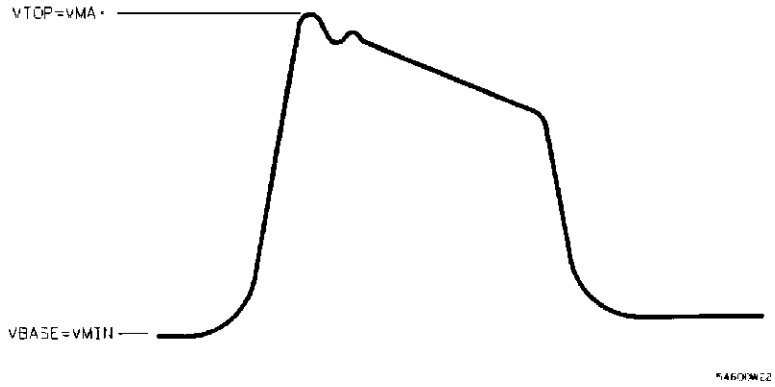
You can measure the following voltage parameters automatically with the oscilloscope peak-to-peak, average, rms, maximum, minimum, top, and base. The following exercise guides you through the Voltage keys by making an rms voltage measurement. Figures 11 and 12 show pulses with some of the voltage measurement points

Figure 11



Pulse where the top and bottom are well-defined

Figure 12



Pulse where the top and bottom are not well-defined

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press `Voltage`.

A softkey menu appears with six softkey choices. Three of the softkeys are voltage measurement functions.

`Source` Selects a channel for the voltage measurement.

`Voltage Measurements` Three voltage measurement choices are available: $V_{p\text{-}p}$, V_{avg}, and V_{rms}. The measurements are determined by voltage histograms of the signal.

`Clear Meas` (clear measurement) Erases any measurement results from the display, and removes the horizontal and vertical cursors from the display.

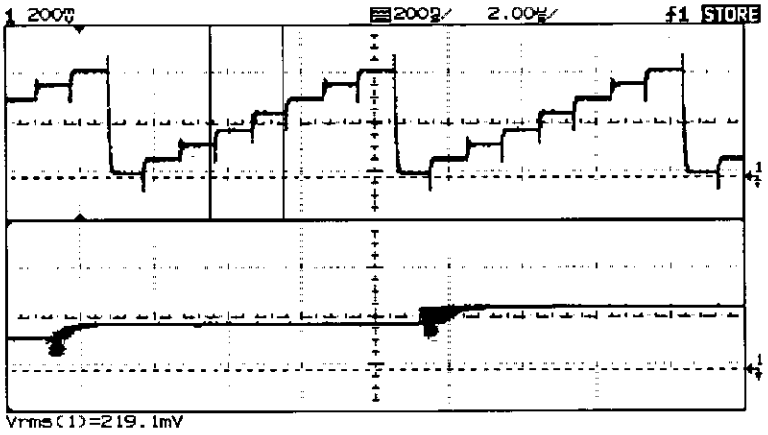
`Next Menu` Replaces the softkey menu with six additional softkey choices.

3 Press the V_{rms} softkey.

The oscilloscope automatically measures the rms voltage and displays the result on the display

The oscilloscope makes automatic measurements on the first pulse or period in the display. Figure 13 shows how to use delayed sweep to isolate a pulse for an rms measurement

Figure 13



Delayed sweep isolates an area of interest for an rms voltage measurement

4 Press the **Next Menu** softkey.

Another voltage measurement softkey menu appears with six additional choices. Four of the softkeys are voltage measurement functions.

Show Meas (show measurement) Displays the horizontal and vertical cursors that show where the measurement was taken on the signal.

Voltage Measurements Four additional voltage measurement choices are available: V_{max}, V_{min}, V_{top}, V_{base}.

Previous Menu Returns to the previous softkey menu

To make cursor measurements

The following steps guide you through the front-panel Cursors key. You can use the cursors to make custom voltage or time measurements on the signal. Examples of custom measurements include rise time measurements from reference levels other than 10-90%, frequency and width measurements from levels other than 50%, channel-to-channel delay measurements, and voltage measurements. See figures 14 through19 for examples of custom measurements.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press [cursors].

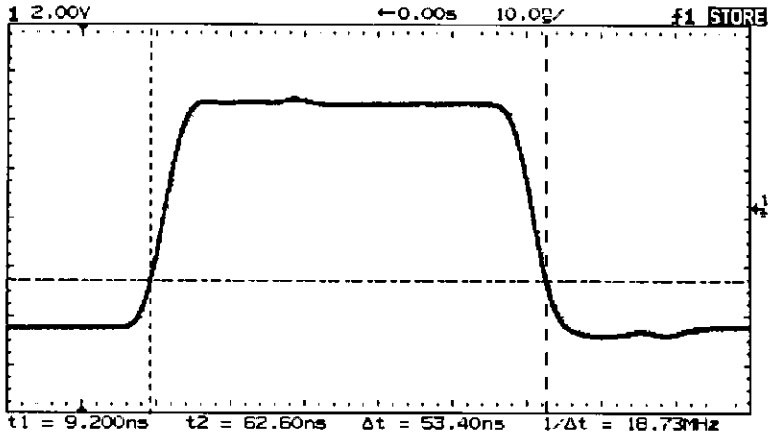
A softkey menu appears with six softkey choices. Four of the softkeys are cursor functions.

Source Selects a channel for the voltage cursor measurements.

Active Cursor There are four cursor choices: V1, and V2 are voltage cursors, while t1, and t2 are time cursors. Use the knob below the Cursors key to move the cursors. When you press the V1 and V2 softkeys simultaneously or the t1 and t2 softkeys simultaneously, the cursors move together

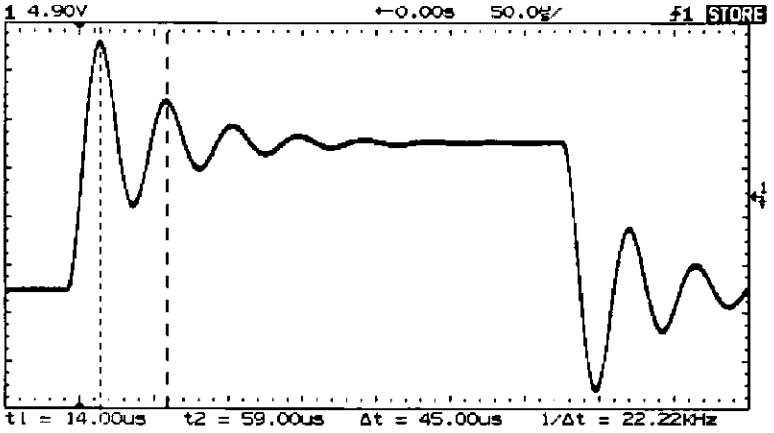
Clear Cursors Erases the cursor readings and removes the cursors from the display

Figure 14



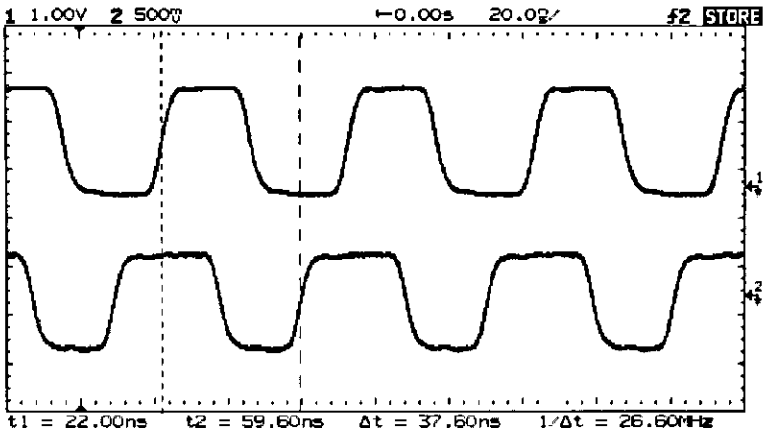
Cursors used to measure pulse width at levels other then the 50% points

Figure 15



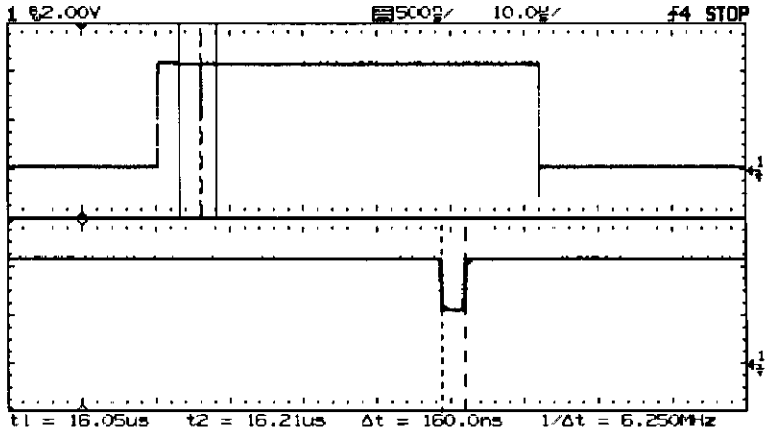
Cursors used to measure the frequency of the ringing on a pulse

Figure 16



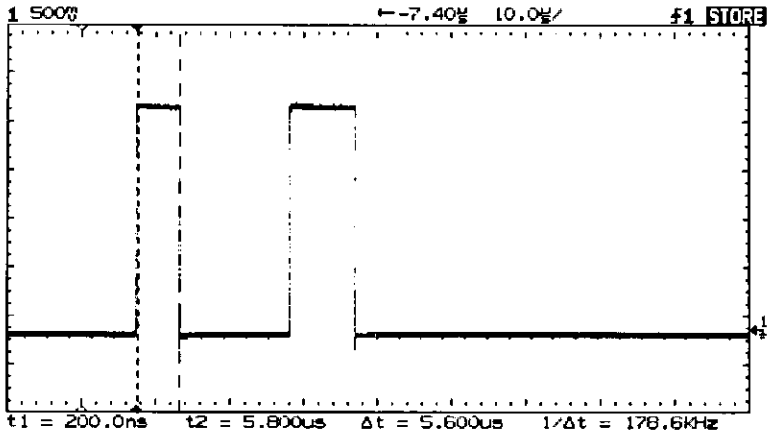
Cursors used to make channel-to-channel delay measurements

Figure 17



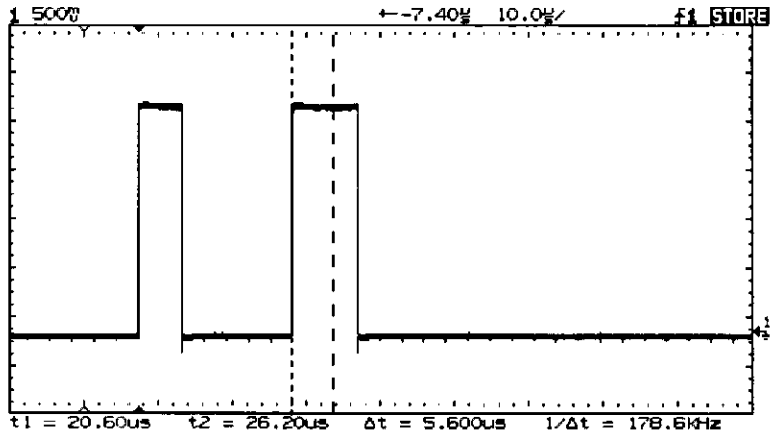
The cursors track delayed sweep. Expand the display with delayed sweep, then characterize the event of interest with the cursors.

Figure 18



Pressing t1 and t2 softkeys simultaneously causes the cursors to move together when the cursor knob is adjusted.

Figure 19



By moving the cursors together, you can check for pulse width variations in a pulse train, as figures 18 and 19 show.

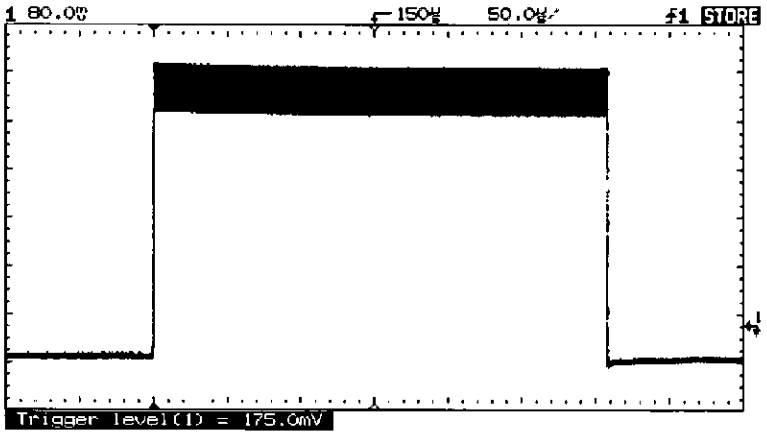
To view asynchronous noise on a signal

The following exercise shows how to use the oscilloscope to view asynchronous noise on a signal that is not synchronous to the period of the waveform

1 Connect a noisy signal to the oscilloscope and obtain a stable display.

Figure 20 shows a waveform with asynchronous noise at the top of the pulse.

Figure 20



Asynchronous noise at the top of the pulse

2 Press Autostore .

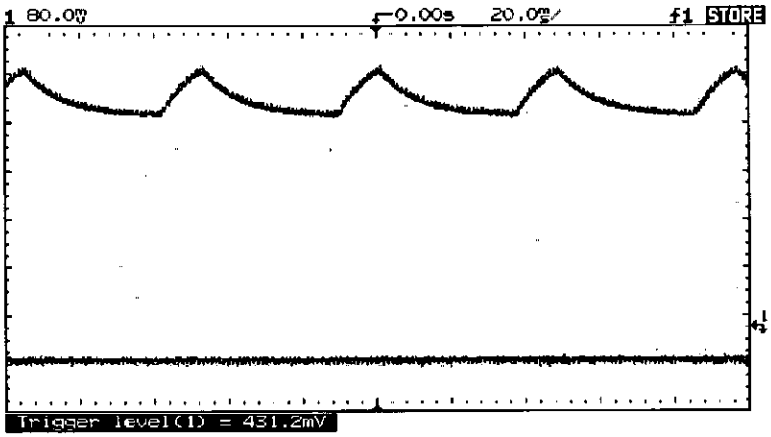
Notice that STORE is displayed in the status line.

3 Set the trigger mode to normal, then adjust the trigger level into the noise region of the signal.

4 Decrease the sweep speed for better resolution of the asynchronous noise.

- To characterize the asynchronous noise signal, use the cursors.

Figure 21



This is a triggered view of the asynchronous noise shown in figure 20

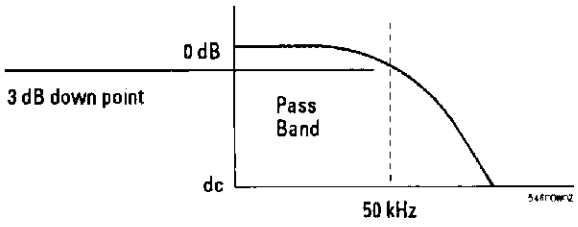
To reduce the random noise on a signal

If the signal you are applying to the oscilloscope is noisy (figure 24), you can set up the oscilloscope to reduce the noise on the waveform (figure 25). First, you stabilize the displayed waveform by removing the noise from the trigger path. Second, you reduce the noise on the displayed waveform.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Remove the noise from the trigger path by turning on either high frequency reject or noise reject.

   High frequency reject (HF reject) adds a low pass filter with the 3 dB point at 50 kHz (see figure 22). You use HF reject to remove high frequency noise such as AM or FM broadcast stations from the trigger path.

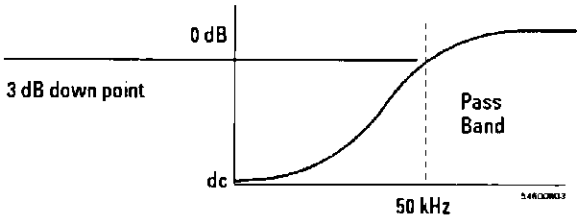
Figure 22



HF reject

Low frequency reject (LF reject) adds a high pass filter with the 3-dB point at 50 kHz (see figure 23) Use LF reject to remove low frequency signals such as power line noise from the trigger path.

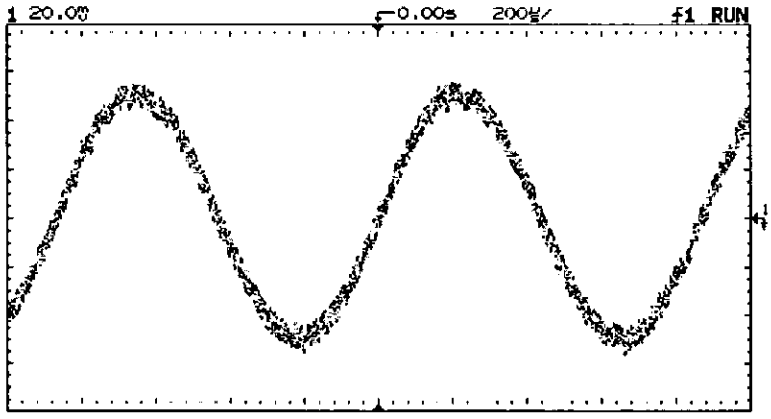
Figure 23



LF reject

Noise reject increases the trigger hysteresis band. By increasing the trigger hysteresis band you reduce the possibility of triggering on noise. However, this also decreases the trigger sensitivity so that a slightly larger signal is required to trigger the oscilloscope.

Figure 24



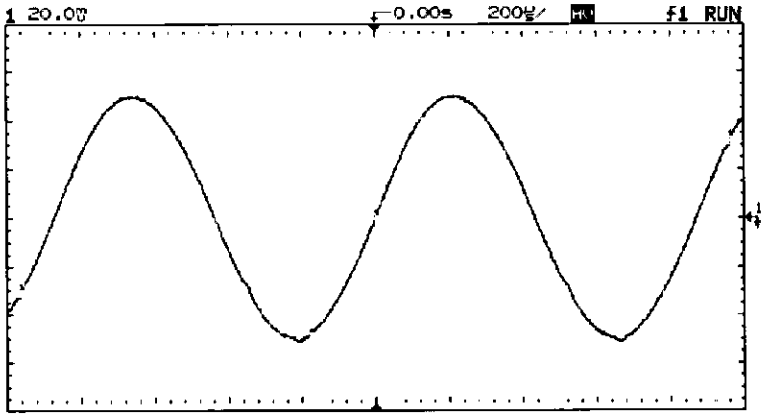
Random noise on the displayed waveform

3 Use averaging to reduce noise on the displayed waveform.

To use averaging follow these steps.

- Press Display , the press the **Average** softkey.
  Notice that **Av** appears in the status line.
- Toggle the **# Average** softkey to select the number of averages that best eliminates the noise from the displayed waveform.
  The **Av** initials in the status line indicates how much of the averaging process is finished, by turning to inverse video as the oscilloscope performs averaging. The higher the number of averages, the more noise that is removed from the display. However, the higher the number of averages, the slower the displayed waveform responds to waveform changes. You need to choose between how quickly the waveform responds to changes and how much noise there is on the signal.

Figure 25



On this waveform, 256 averages were used to reduce the noise

To analyze video waveforms

The TV sync separator in the oscilloscope has an internal clamp circuit. This removes the need for external clamping when you are viewing unclamped video signals TV triggering requires two vertical divisions of display, either channel 1 or channel 2 as the trigger source, and the selection of internal trigger. Turning the trigger level knob in TV trigger does not change the trigger level because the trigger level is automatically set to the sync pulse tips

For this exercise we connected the oscilloscope to the video output terminals on a television. Then we set up the oscilloscope to view these parts of a TV signal: the second vertical interval with delayed sweep windowed on the vertical interval test signals (VITS) and the IRE displayed full screen.

1 Connect a TV signal to channel 1, then press [Autoscale].

2 Press [Display], then press the **Peak Det** softkey.

3 Press [Mode], then press the **TV** softkey.

4 Press [Slope/Coupling], then press the **Field 2** softkey.

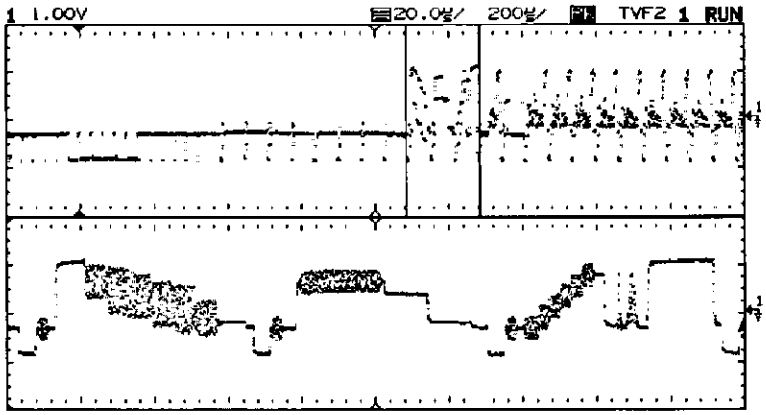
Polarity Selects either positive or negative sync pulses.
Field 1 Triggers on the field 1 portion of the video signal.
Field 2 Triggers on the field 2 portion of the video signal.
Line Triggers on all the TV line sync pulses.
HF Rej Controls a 500 kHz low pass filter in the trigger path.

5 Set the time base to 200 μs/div, then center the signal on the display with the delay knob (delay about 800 μs).

6 Press Main/Delayed, then press the **Delayed** softkey.

7 Set the delayed sweep to 20 μs/div, then set the expanded portion over the VITS (delay about 988.8 μs).

Figure 26

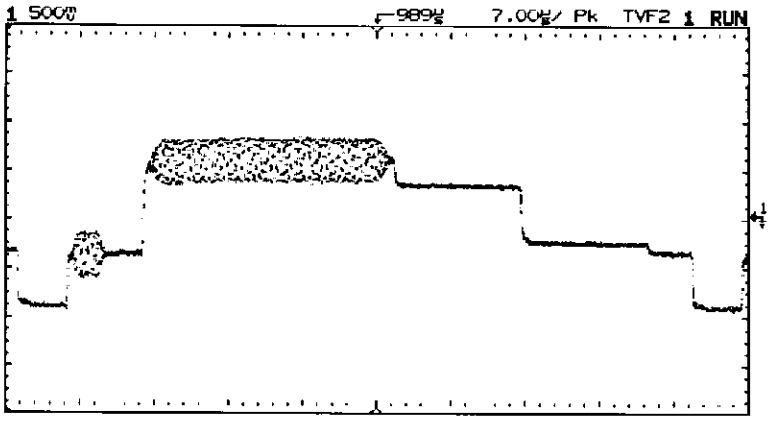


Second vertical interval windowed on the VITS

8 Press Main/Delayed, then press the **Main** softkey.

9 Use the horizontal vernier to change the time base to 7 μs/div, then center the signal on the display with the delay knob (delay about 989 μs).

Figure 27



Full screen display of the IRE

Delay in TV line units hint

HP 54600-series oscilloscopes with system ROM versions 2.1 and greater have the ability to display delay in TV-line units. Using the TV field trigger mode activates this line-counting feature. When Field 1 or Field 2 is selected as the trigger source, delay can be set in terms of time or line number.

Both-fields triggering in the HP 54602A hint

The HP 54602A can trigger on the vertical sync pulse in both TV fields at the same time. This allows you to view noninterlaced video signals which are common in today's computer monitors. To trigger on both sync pulses, press Field 1 and Field 2 at the same time.

TV trigger operating hints

The color burst never really changes phase, it just looks doubled triggered because its frequency is an odd multiple of one half the line frequency.

When looking at live video (usually a field), use peak detect to improve the appearance of the display.

When making cursor measurements, use Autostore since you are usually looking for pulse flatness and extremes.

When using line trigger, use minimum holdoff to display all the lines. Due to the relationship between the horizontal and vertical sync frequencies the display looks like it is untriggered, but it is very useful for TV waveform analysis and adjustment because all of the lines are displayed

To save or recall traces

The oscilloscope has two pixel memories for storing waveforms. The following exercise guides you through how to store and recall waveforms from pixel memories.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press [Trace].

A softkey menu appears with five softkey selections. Four of the softkeys are trace memory functions.

Trace Selects memory 1 or memory 2.

Trace Mem Turns on or off the selected memory.

Save to Saves the waveform to the selected memory. The front-panel setup is saved to a separate memory location.

Clear Erases the selected memory.

Recall Setup Recalls the front-panel setup that was saved with the waveform.

3 Toggle the **Trace** softkey to select memory 1 or memory 2.

4 Press the **Save to** softkey.

The current display is copied to the selected memory.

5 Turn on the **Trace Mem** softkey to view the stored waveform.

The trace is copied from the selected trace memory and is displayed in half bright video

The automatic measurement functions do not operate on stored traces. Remember, the stored waveforms are pictorial information rather than stored data.

- If you have not changed the oscilloscope setup, use the cursors to make the measurements
- If you have changed the oscilloscope setup, press the **Recall Setup** softkey. Then,use the cursors to make the measurements.

Trace memory operating hint

The standard oscilloscope has volatile trace memories. When you add an interface module to the oscilloscope, the trace memories become nonvolatile.

To use the XY display mode

The XY display mode converts the oscilloscope from a volts versus time display to a volts versus volts display. You can use various transducers so the display could show strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency. This exercise shows a common use of the XY display mode by measuring the phase shift between two signals of the same frequency with the Lissajous method.

1. Connect a signal to channel 1, and a signal of the same frequency but out of phase to channel 2.
2. Press [Autoscale], press [Main/Delayed], then press the **XY** softkey.
3. Center the signal on the display with the Position knobs, and use the Volts/Div knobs and the vertical **Vernier** softkeys to expand the signal for convenient viewing.

$$\sin\theta = \frac{A}{B} \text{ or } \frac{C}{D}$$

Figure 28

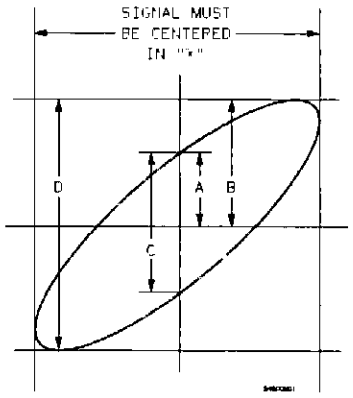
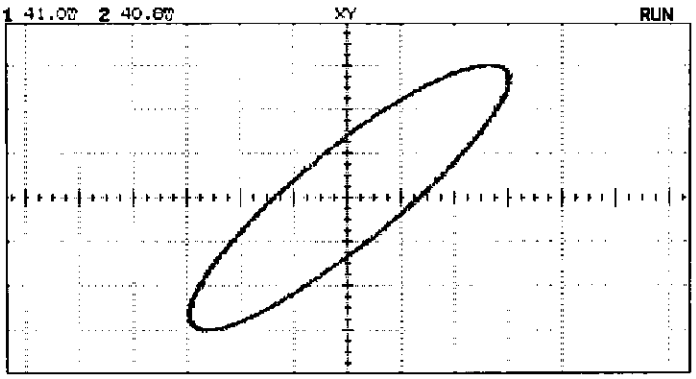


Figure 29

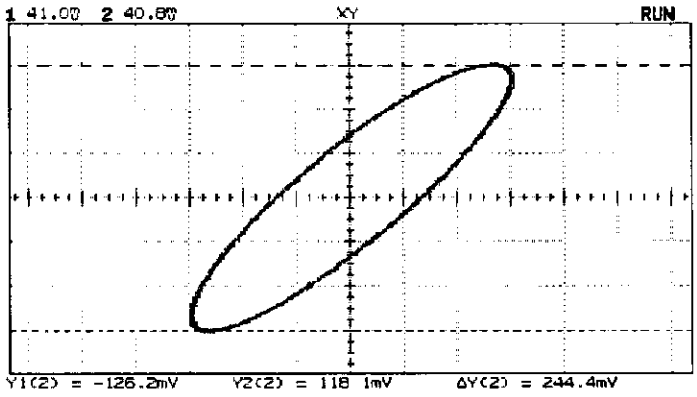


4 Press Cursors .

5 Set the Y2 cursor to the top of the signal, and set Y1 to the bottom of the signal.

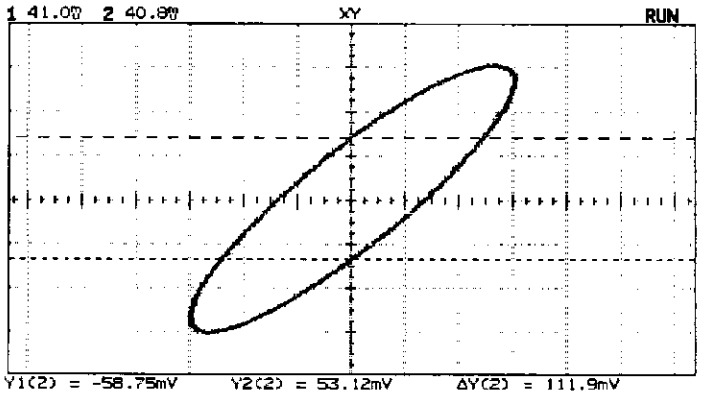
Note the ΔY value at the bottom of the display. In this example we are using the Y cursors, but you could have used the X cursors instead. If you use the X cursors, make sure you center the signal in the Y axis.

Figure 30



6 Move the Y1 and Y2 cursors to the center of the signal.
Again, note the ΔY value.

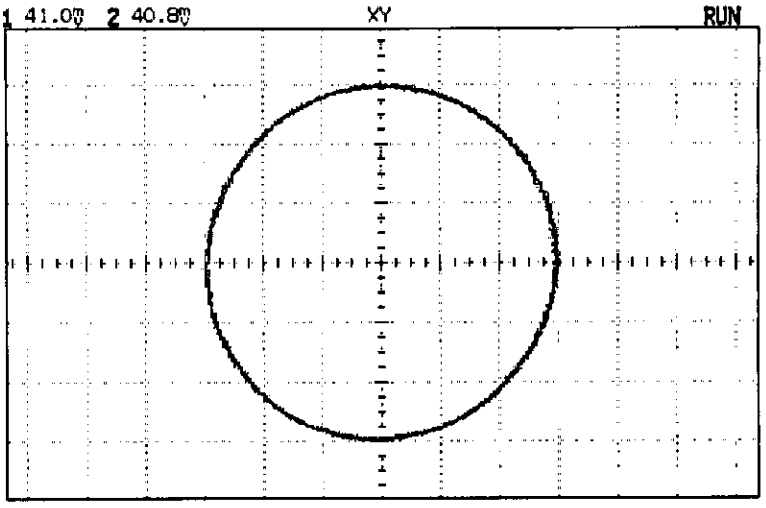
Figure 31



7 Calculate the phase difference using formula below.

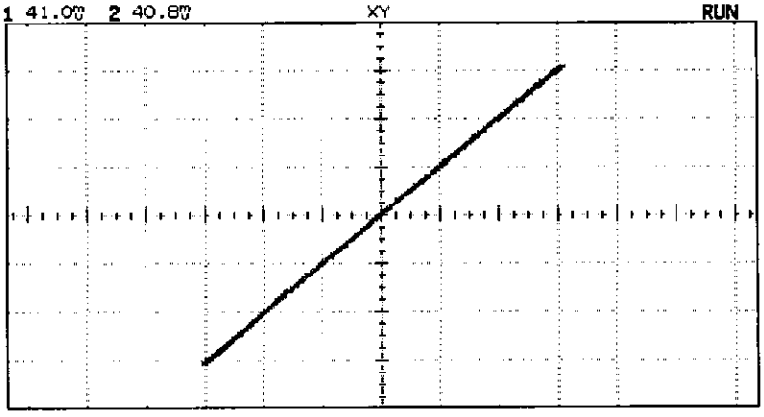
$$\sin\theta = \frac{second\ \Delta Y}{first\ \Delta Y} = \frac{111.9}{244.4} = 27.25 \text{ degrees of phase shift.}$$

Figure 32



Signals are 90° out of phase

Figure 33



Signals are in phase

XY display mode operating hint

When you select the XY display mode, the time base is turned off. Channel 1 is the X-axis input, channel 2 is the Y-axis input, and channel 4 (external trigger in the HP 54600A) is the Z-axis input. If you only want to see portions of the Y versus X display, use the Z-axis input. Z-axis turns on and off the trace (analog oscilloscopes called this Z-blanking because it turned the beam on and off). When Z is low (<1.3 V), Y versus X is displayed; when Z is high (>1.3 V), the trace is turned off.

To save or recall front-panel setups

There are 16 memories for storing front-panel setups. Saving front-panel setups can save you time in situations where several setups are repeated many times

1 Press [Setup].

2 To change the selected memory location, press either the left-most softkey or turn the knob closest to the Cursors key.

3 Press the **Save** softkey to save a front-panel setup, then press the **Recall** softkey to recall a front-panel setup.

3

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Service

Service

If the oscilloscope is under warranty, you must return it to Hewlett-Packard for all service work covered by the warranty. See "To return the oscilloscope to Hewlett-Packard," on page 66. If the warranty period has expired, you can still return the oscilloscope to Hewlett-Packard for all service work. Contact your nearest Hewlett-Packard Sales Office for additional details on service work.

If the warranty period has expired and you decide to service the oscilloscope yourself, the instructions in this chapter can help you keep the oscilloscope operating at optimum performance.

This chapter is divided into the following four sections:

- Verifying Oscilloscope Performance on page 67
- Adjusting the Oscilloscope on page 85
- Troubleshooting the Oscilloscope on page 96
- Replacing Parts in the Oscilloscope on page 105

Service should be performed by trained service personnel only. Some knowledge of the operating controls is helpful, and you may find it helpful to read chapter 1, "The Oscilloscope at a Glance," starting on page 7.

Table 2

Recommended list of test equipment to service the oscilloscope

Equipment	Critical specifications	Recommended Model/Part	Use
Constant amplitude signal generator	100 MHz, Constant amplitude ±1% (250 MHz for HP 54602A)	Tek SG503 Tek TM501	P
Digital multimeter	0.1 mV resolution, better than 0.01% accuracy	HP 34401A	P, A, T
Oscilloscope	100 MHz	HP 54501A	T
Power supply	14 mV to 35 Vdc, 0.1 mV resolution	HP 6114A	P
Probe	10:1 division ratio	HP 10432A	T
Pulse generator	Rise time < 875 ps	PSPL 1107B TD and PSPL 1110B Driver	A
Pulse generator	10 kHz, 500 mV p-p, rise time <5 ns	HP 8112A	A
Time marker generator	Stability 5 ppm after 1/2 hour	TG 501A and TM 503A	P
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C	P, A
Power splitter	Outputs differ <0.15 dB	HP 11667B	P
Shorting cap	BNC	HP 1250-0774	P
Adapter	SMA (f) to BNC (m)	HP 1250-1787	A
Adapter	BNC (f-f)	HP 1250-0080	A
Adapter	BNC tee (m) (f) (f)	HP 1250-0781	A
Adapter	N (m) to BNC (f), Qty 3	HP 1250-0780	P
Adapter	BNC (f) to dual banana (m)	HP 1251-2277	P
Cable	BNC, Qty 3	HP 10503A	P, A
Cable	BNC, 9 inches, Qty 2	HP 10502A	A

Additional equipment needed if you perform the alternate bandwidth test when verifying oscilloscope performance.

Signal generator	1 to 100 MHz at 200 mV (250 MHz for HP 54602A)	HP 8656B opt 001	P
Power meter and Power Sensor	1 to 100 MHz ±3% accuracy (250 MHz for HP 54602A)	HP 436A and HP 8482A	P
Cable	Type N (m) 24 inch	HP 11500B	P
Adapter	Type N (m) to BNC (m)	HP 1251-0082	P

To return the oscilloscope to Hewlett-Packard

Before shipping the oscilloscope to Hewlett-Packard, contact your nearest Hewlett-Packard Sales Office for additional details

1 Write the following information on a tag and attach it to the oscilloscope.

- Name and address of owner
- Model number
- Serial number
- Description of service required or failure indications

2 Remove all accessories from the oscilloscope.

The accessories include the power cord, probes, cables, and any modules attached to the rear of the oscilloscope. Do not ship accessories back to Hewlett-Packard unless they are associated with the failure symptoms.

3 Protect the control panel with cardboard.

4 Pack the oscilloscope in styrofoam or other shock-absorbing material and place it in a strong shipping container.

You can use either the original shipping containers, or order materials from an HP Sales Office Otherwise, pack the oscilloscope in 3 to 4 inches of shock-absorbing material to prevent movement inside the shipping container.

5 Seal the shipping container securely.

6 Mark the shipping container as FRAGILE.

Verifying Oscilloscope Performance

This section shows you how to verify the electrical performance of the oscilloscope, using the performance characteristics in chapter 4 as the standard. The characteristics checked are dc calibrator, voltage measurement accuracy, bandwidth, horizontal accuracy, and trigger sensitivity.

You should verify the performance of the oscilloscope when you first receive it, and every 12 months or after 2,000 hours of operation. Also, make sure you allow the oscilloscope to operate for at least 30 minutes before you begin the following procedures.

Perform self-calibration first

For the oscilloscope to meet all of the verifications tests in the ambient temperature where it will be used, the self-calibration tests described on page 88 should first be performed Allow the unit to operate for at least 30 minutes before performing the self-calibration.

Each procedure lists the recommended equipment for the test. You can use any equipment that meets the critical specifications. However, the procedures are based on the recommended model or part number.

On page 84 is a test record for recording the test results of each procedure. Use the test results to gauge the performance of the oscilloscope over time.

To check the output of the DC CALIBRATOR

In this test you measure the output of the DC CALIBRATOR with a multimeter. The DC CALIBRATOR is used for self-calibration of the oscilloscope. The accuracy is not specified, but it must be within the test limits to provide for accurate self-calibration.

Test limits: 5.000 V ±10 mV and 0.000 V ± 500 μV.

Table 1 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Digital Multimeter	0.1% mV revolution, better than 0.01% accuracy	HP 34401A
Cable	BNC	HP 10503A

1. Connect a multimeter to the rear panel DC CALIBRATOR connector.
2. Press [Print/Utility].
3. Press the **Self Test** softkey, then press the **DAC** softkey.

   The multimeter should measure 0.00 V dc ± 500 μV. If the result is not within the test limits, see "Troubleshooting the oscilloscope," on page 96.
4. Press any key to continue the test.

   The multimeter should read 5.000 V ±10 mV. If the result is not within the test limits, see "Troubleshooting the oscilloscope," on page 96.

To verify voltage measurement accuracy

In this test you verify the voltage measurement accuracy by measuring the output of a power supply using dual cursors on the oscilloscope, and comparing the results with a multimeter.

Test limits: ±1.5% of reading ±0.4% of full scale

Table 2 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Power supply	14 mV to 35 Vdc, 0.1 mV resolution	HP 6114A
Digital multimeter	Better than 0.1% accuracy	HP 34401A
Cable	BNC, Qty 2	HP 10503A
Shorting cap	BNC	HP 1250-0774
Adapter	BNC (f) to banana (m)	HP 1251-2277
Adapter	BNC tee (m) (f) (f)	HP 1250-0781

1 Set up the oscilloscope.
   a Press [Setup], then press the **Default Setup** softkey.
   b Press [Voltage], then press the **V avg** softkey.
   c Set the Volts/Div to the first line of table 3.
   d Adjust the channel 1 Position knob to place the baseline near (but not at) the bottom of the display.
2 Press [Cursors], then press the **V1** softkey.
3 Using the cursors knob, set the V1 cursor on the baseline.
   If you are in an electrically noisy environment, it can help to place a shorting cap on the input BNC connector when positioning V1.
4 Connect the power supply to the oscilloscope and to the multimeter, using the BNC tee and cables.
5 Set the power supply output to the first line in table 3.

6 Press the **v2** softkey, then position the V2 cursor to the baseline.

The ΔV value at the bottom of the display should be within the test limits of table 3. If a result is not within the test limits, see "Troubleshooting the Oscilloscope," on page 96.

7 Continue checking the voltage measurement accuracy with the remaining lines in table 3.

Table 3 **Equipment Required**

Volts/Div setting	Power supply setting	Test limits		
5 V/Div	35 V	34 315 V	to	35.685 V
2 V/Div	14 V	13 726 V	to	14.274 V
1 V/Div	7 V	6.863 V	to	7 137 V
0 5 V/Div	3 5 V	3.4315 V	to	3 5685 V
0.2 V/Div	1.4 V	1 3726 V	to	1 4274 V
0.1 V/Div	700 mV	686 3 mV	to	713.7 mV
50 mV/Div	350 mV	343 15 mV	to	356.85 mV
20 mV/Div	140 mV	137.26 mV	to	142.74 mV
10 mV/Div	70 mV	68 63 mV	to	71 37 mV
5 mV/Div*	35 mV	34 155 mV	to	35 845 mV
2 mV/Div*	14 mV	13 47 mV	to	14 53 mV

8 Disconnect the power supply from the oscilloscope, then repeat steps 1 to 7 for channel 2 (channels 2 to 4 on the HP 54601A and HP 54602A). On the HP 54601A and HP 54602A, channels 3 and 4, check the 0.5 V/div and 0.1 V/div range only.

*Full scale is defined as 80 mV on the 5 mV/div and 2 mV/div ranges.

To verify bandwidth

In this test you verify the bandwidth of the oscilloscope by using a constant amplitude signal generator The frequency of the signal generator is set to 250 kHz to establish a reference level Then, the frequency is changed to the upper bandwidth limit and the level is checked to see if it is 3 dB from the reference level

The following procedure is a simple method to check bandwidth. However, there is a possibility of measurement uncertainty with a constant amplitude signal generator. If you need a more exact procedure for checking bandwidth see, "To verify the bandwidth (alternate method)" on page 74.

Test limits:

HP 54600A and HP 54601A, all channels (−3 dB)
dc to 100 MHz
ac coupled 10 Hz to 100 MHz.

HP 54602A
Channels 1 & 2 (–3 dB)
dc to 150 MHz
ac coupled 10 Hz to 150 MHz.
Channels 3 & 4 (–3 dB)
dc to 250 MHz.

Table 4 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Constant amplitude signal generator	100 MHz, Constant amplitude ±1% (250 MHz for HP 54602A)	Tek SG503/Tek TM501
Cable	BNC	HP 10503A
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Using the 50-Ω feedthrough and the BNC cable, connect the signal generator to channel 1 of the oscilloscope.
2 Set the frequency of the signal generator to 250 kHz and the amplitude to about 800 mV.
3 Press Autoscale.
4 Adjust the output of the signal generator for exactly 8 divisions of vertical deflection.
5 Change the frequency of the signal generator to the value shown below for your instrument.

Selected Channel	Signal Generator Frequency Setting		
	HP 54600A	HP 54601A	HP 54602A
Channel 1	100 MHz	100 MHz	150 MHz
Channel 2	100 MHz	100 MHz	150 MHz
Channel 3	—	100 MHz	250 MHz
Channel 4	—	100 MHz	250 MHz

6 Change the sweep speed of the oscilloscope to 5 ns/div and observe the display.
The vertical amplitude of the signal on the display should be equal to or greater than 5.66 divisions (−3 dB point). If the result is not ≤ −3 dB, see "Troubleshooting the Oscilloscope," on page 96.
7 Repeat steps 1 through 6 for channel 2 (channels 2 to 4 on the HP 54601A and HP 54602A).

To verify bandwidth (alternate method)

In this test you verify the bandwidth of the oscilloscope by using a power meter and power sensor to set the output of a signal generator at 1 MHz and the upper bandwidth limit. You use the peak-to-peak voltage at 1 MHz and the upper bandwidth limit to calculate the bandwidth response of the oscilloscope.

Test limits

HP 54600A and HP 54601A, all channels (−3 dB)
dc to 100 MHz
ac coupled 10 Hz to 100 MHz

HP 54602A
Channels 1 & 2 (–3 dB)
dc to 150 MHz
ac coupled 10 Hz to 150 MHz
Channels 3 & 4 (–3 dB)
dc to 250 MHz

Table 5 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Signal generator	1 to 100 MHz at 200 mV (250 MHz for HP 54602A)	HP 8656B opt 001
Power meter and Power Sensor	1 to 100 MHz ±3% accuracy (250 MHz for HP 54602A)	HP 436A and HP 8482A
Power splitter	Outputs differ by <0.15 dB	HP 11667B
Cable	Type N (m), 24 inch	HP 11500B
Adapter	Type N (m) to BNC (m)	HP 1251-0082
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Connect the equipment.
   a Connect the signal generator to the input of the power splitter.
   b Connect the power sensor to one output of the power splitter, and connect channel 1 of the oscilloscope to the other power splitter output (put the 50 Ω feedthrough at the input of the oscilloscope).
2 Set up the oscilloscope.
   a Press [Setup], then press the **Default Setup** softkey.
   b Set the time base to 500 ns/div.
   c Set channel 1 to 100 mV/div.
   d Press [Display], then press the **Average** softkey.
   e Toggle the **# Average** softkey to select **8** averages.
3 Set the signal generator for 1 MHz at about 5.6 dBm.
   Notice that the signal on the display is about 5 cycles and six divisions of amplitude.

4 Press [Voltage], then press the **Vp-p** softkey.

Wait a few seconds for the measurement to settle (averaging is complete), then note the Vp-p reading from the bottom of the display
Vp-p = _____ mV.

5 Set the calibration factor percent of the power meter to the 1 MHz value from the calibration chart on the probe, then press dB (REF) on the power meter to set a 0 dB reference.

6 Change the frequency of the signal generator to the value shown below for your instrument.

Selected Channel	Signal Generator Frequency Setting		
	HP 54600A	HP 54601A	HP 54602A
Channel 1	100 MHz	100 MHz	150 MHz
Channel 2	100 MHz	100 MHz	150 MHz
Channel 3	—	100 MHz	250 MHz
Channel 4	—	100 MHz	250 MHz

7 Set the calibration factor of the power meter to 100 MHz percent value from the chart on the probe.

Adjust the amplitude of the signal generator for a power reading as close as possible to 0.0 dB (REL). Power meter reading = _____ dB.

8 Change the time base to 5 ns/div.

Wait a few seconds for the measurement to settle (averaging is complete), then note the Vp-p reading from the bottom of the display.
Vp-p = _____ mV.

9 Calculate the response using the following formula.

$$20 \log_{10} \left(\frac{step\ 8\ result}{step\ 4\ result} \right)$$

10 Correct the result from step 9 with any difference in the power meter reading from step 7. Make sure you observe all number signs.

For example:
Result from step 9 = −2.3 dB
Power meter reading from step 7 = −0.2 dB (REL)
True response = (−2.3) − (−0.2) = −2.1 dB
The true response should be ≤ −3 dB

If the result is not ≤ −3 dB, see "Troubleshooting the Oscilloscope," on page 96.

11 Repeat steps 1 to 10 for channel 2 (channels 2 to 4 on the HP 54601A and HP 54602A).

When you measure the bandwidth on channels 3 and 4, use the 0.1 V/Div range.

To verify horizontal Δt and 1/Δt accuracy

In this test you verify the horizontal Δt and 1/Δt accuracy by measuring the output of a time mark generator with the oscilloscope.

Test limits: ±0.01% ±0.2% of full scale ±200 ps.

Table 6 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Time marker generator	Stability 5 ppm after 1/2 hour	TG 501A and TM 503A
Cable	BNC	HP 10503A
Termination	50 Ω, BNC connectors (m) (f)	HP 10100C

1 Connect the time mark generator to channel 1 using the feedthrough at the oscilloscope input. Then, set the time mark generator for 0.1 ms markers.

2 Setup the oscilloscope.

a Press [Setup], then press the **Default Setup** softkey.

b Press [Autoscale].

c Set the time base to 20 μs/div.

d Adjust the trigger level to obtain a stable display.

3 Press [Time], then press the **Freq** and **Period** softkeys.

You should measure the following.
Frequency 10 kHz, test limits are 9.899 kHz to 10.10 kHz.
Period 100 μs, test limits are 98.98 μs to 101.01 μs.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 96.

4 Change the time mark generator to 1 μs, and change the time base to 200 ns/div. Adjust the trigger level to obtain a stable display.

5 Press [Time], then press the **Freq** and **Period** softkeys.

You should measure the following.
Frequency 1 MHz, test limits are 989.8 kHz to 1.0104 MHz.
Period 1 μs, test limits are 989.7 ns to 1.010 μs.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 96.

6 Change the time mark generator to 10 ns, and change the time base to 5 ns/div. Adjust the trigger level to obtain a stable display.

7 Press [Time], then press the **Freq** and **Period** softkeys.

You should measure the following:

Frequency 100 MHz, test limits are 97.078 MHz to 103.1 MHz.

Period 10 ns, test limits are 9.699 ns to 10.30 ns.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 96.

To verify trigger sensitivity

In this test you verify the trigger sensitivity by applying 25 MHz to the oscilloscope. The amplitude of the signal is decreased to the specified levels, then you check to see if the oscilloscope is still triggered. You then repeat the process at the upper bandwidth limit.

Test limits:

Internal trigger

HP 54600A and HP 54601A, all channels
dc to 25 MHz, 0.35 div or 3.5 mV p-p
dc to 100 MHz, 1 div or 10 mV p-p

HP 54602A
Channels 1 & 2
dc to 25 MHz, 0.35 div or 3.5 mV p-p
dc to 150 MHz, 1 div or 10 mV p-p
Channels 3 & 4
dc to 25 MHz, 0.35 div or 3.5 mV p-p
dc to 250 MHz, 1 div or 10 mV p-p

External trigger (HP 54600A only)
dc to 25 MHz, 50 mV p-p
dc to 100 MHz, 100 mV p-p

Table 7 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Signal generator	25 MHz and 100 MHz sine waves (25 MHz and 250 MHz for HP 54602A)	Tek SG 503/Tek TM 501
Power splitter (HP 54600A only)	Outputs differ <0.15 dB	HP 11667B
Cable	BNC, Qty 3	HP 10503A
Adapter	N (m) to BNC (f), Qty 3	HP 1250-0780
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

Internal Trig Sensitivity

1 Press [Setup], then press the **Default Setup** softkey.
2 Connect the signal generator to channel 1.
3 Verify the trigger sensitivity at 25 MHz and 0.35 divisions.
   a Set the signal generator to 25 MHz and about 50 mV.
   b Press [Autoscale].
   c Decrease the output of the signal generator until there is 0.35 vertical divisions of the signal displayed.

   The trigger should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 96.
4 Verify the trigger sensitivity at 1 division for the frequencies shown below.
   a Change the output of the signal generator to the frequency shown below for your instrument and set amplitude to about 100 mV.

Selected Channel	Signal Generator Frequency Setting		
	HP 54600A	HP 54601A	HP 54602A
Channel 1	100 MHz	100 MHz	150 MHz
Channel 2	100 MHz	100 MHz	150 MHz
Channel 3	—	100 MHz	250 MHz
Channel 4	—	100 MHz	250 MHz

   b Press [Autoscale].
   c Decrease the output of the signal generator until there is 1 vertical division of the signal displayed.

   The trigger should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 96.
5 Repeat steps 1 through 4 for channel 2 on the HP 54600A (channels 2 to 4 on the HP 54601A and HP 54602A).

External Trig Sensitivity

6 Verify the external trigger sensitivity at 100 MHz and 100 mV p-p (HP 54600A only).

a Press [Source], then press the **Ext** softkey.

b Use the power splitter to connect the signal generator to the channel 1 input and to the external trigger input.

c Change the output of the signal generator to 100 MHz and 200 mV p-p.

The power splitter divides the 200 mV so that 100 mV is applied to each of the oscilloscope inputs.

The oscilloscope triggering should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 96.

7 Verify the external trigger sensitivity at 25 MHz and 50 mV p-p (HP 54600A only).

a Change the output of the signal generator to 25 MHz at about 100 mV.

b Press [Autoscale].

The oscilloscope triggering should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 96.

HEWLETT PACKARD

HP 54600A and HP 54601A
Performance Test Record

Date _____

Serial No. _____ Test by _____

Test Interval _____ Work Order No _____

Recommended Next Testing _____ Temperature _____

Output of dc calibrator	**Limits**	**Result**
	4.990 V to 5.010 V	_____

Voltage measurement accuracy

Range	**Reading**	**Test Limits**	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
5 V/Div	35 V	34.315 V to 35.685 V	_____	_____	_____	_____
2 V/Div	14 V	13.726 V to 14.274 V	_____	_____	_____	_____
1 V/Div	7 V	6.863 V to 7.137 V	_____	_____	_____	_____
500 mV/Div	3.5 V	3.4315 V to 3.5685 V	_____	_____	_____	_____
200 mV/Div	1.4 V	1.3726 V to 1.4274 V	_____	_____	_____	_____
100 mV/Div	700 mV	686.3 mV to 713.7 mV	_____	_____	_____	_____
50 mV/Div	350 mV	343.15 mV to 356.85 mV	_____	_____	_____	_____
20 mV/Div	140 mV	137.26 mV to 142.74 mV	_____	_____	_____	_____
10 mV/Div	70 mV	68.63 mV to 71.37 mV	_____	_____	_____	_____
5 mV/Div	35 mV	34.155 mV to 35.845 mV	_____	_____	_____	_____
2 mV/Div	14 mV	13.47 mV to 14.53 mV	_____	_____	_____	_____

Bandwidth	**Test Limits**	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
	≤ −3 dB	_____	_____	_____	_____

Horizontal Δt and 1/Δt accuracy

	Reading	**Test Limits**	**Results**
Frequency	10 kHz	9.899 kHz to 10.10 kHz	_____
Period	100 μs	98.98 μs to 101.01 μs	_____
Frequency	1 MHz	989.8 kHz to 1.0104 MHz	_____
Period	1 μs	989.7 ns to 1.010 μs	_____
Frequency	100 MHz	97.078 MHz to 103.1 MHz	_____
Period	10 ns	9.699 ns to 10.30 ns	_____

Trigger sensitivity	**Test Limits**	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
Internal trigger	25 MHz at 0.35 divisions	_____	_____	_____	_____
Internal trigger					
HP 54600A/HP 54601A	100 MHz at 1 division	_____	_____	_____	_____
HP 54602A, Chan 1 & 2	150 MHz at 1 division	_____	_____		
HP 54602A, Chan 3 & 4	250 MHz at 1 division			_____	_____
		External			
External trigger (HP 54600A)	100 MHz at 100 mV p-p	_____			
	25 MHz at 50 mV p-p	_____			

Adjusting the Oscilloscope

This section explains how to adjust the oscilloscope so that it is at optimum operating performance. You should perform the hardware adjustments periodically as indicated below.

- Hardware at 12 months or 2,000 hours of operation
- Firmware at 6 months or 1000 hours of operation, or if ambient temperature is greater than 10 °C from the calibration temperature, or if the user desires to maximize the measurement accuracy

The amount of use, environmental conditions, and your past experience with other instruments can help you to determine if you need a shorter adjustment interval.

Make sure you allow the oscilloscope to warm up for at least 30 minutes before you start the adjustments.

To adjust the power supply

On the power supply there is only one adjustment and that is for the +5.1 V. The other voltages are based on the +5.1 V adjustment. In this procedure you use a multimeter to measure the +5.1 V, and if necessary, you adjust the supply to within tolerance.

Table 8 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Digital multimeter	0.1 mV resolution, accuracy ±0.05%	HP 34401A

1 Set up the oscilloscope for the voltage adjustment.

a Turn off the oscilloscope.

b Remove the cover from the oscilloscope.

c Place the oscilloscope on its side.

d Connect the negative lead of the digital multimeter to a ground point on the oscilloscope.

e Turn on the oscilloscope.

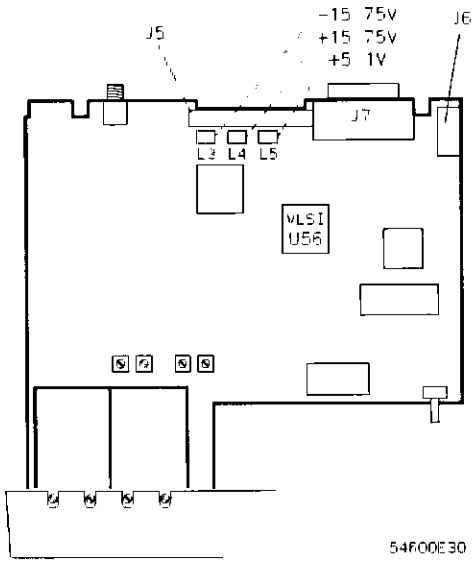
2 Measure the power supply voltages at L3, L4, and L5 on the system board.

Make sure that the voltage measurements are within the following tolerances.

+5.1 V	±150 mV (+4.95 V to +5.25 V)
+15.75 V	±787 mV (+14.96 V to +16.54 V)
− 15.75 V	±787 mV (−14.96 V to −16.54 V)

If the +5.1 V measurement is out of tolerance, adjust the +5.1 V adjustment on the power supply. The ±15.75 V supplies are not adjustable and are dependent upon the +5.1 V supply. If adjusting the power supply does not bring all the voltages within tolerance, see "Troubleshooting the Oscilloscope," on page 96.

Figure 34



To perform the self-calibration

In this procedure you load the default calibration factors to give a known starting point for the firmware calibration. *However, once the default calibration factors are loaded, you must perform the remainder of the firmware calibration to maintain the accuracy of the oscilloscope.*

Table 9 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Pulse generator	100 kHz, 1 V p-p, rise time <5 ns	HP 8112A
Cable	BNC, 3 feet	HP 10503A
Cable	BNC, 9 inches, Qty 2	HP 10502A
Adapter	BNC tee (m) (f) (f)	HP 1250-0781
Adapter	BNC (f-f)	HP 1250-0080
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Check the rear panel DC CALIBRATOR output level.

If you are not sure how to check the DC CALIBRATOR, see "To check the output of the DC CALIBRATOR," on page 68.

2 Load the default calibration factors.

a Set the rear-panel CALIBRATION switch to UNPROTECTED (up position).

b Press `Print/Utility` , then press the **`Self Cal Menu`** softkey.

c Press the **`Load Defaults`** softkey.

Vertical self cal

3 After the message "**Default calibration factors loaded**" is displayed on the lower left side of the display, press the **Vertical** softkey.

4 Follow the instructions on the display, then press the **Continue** softkey.

The display prompts instruct you to connect the rear panel DC CALIBRATOR output first to channel 3, then to channel 1, then to channel 4, and finally to channel 2 (Channels 1 and 2 only on the HP 54600A)

5 After the message "**Press Continue to return to calibration menu**" appears on the display, press the **Continue** softkey.

6 Connect a pulse generator set to 100 kHz and 1 V p-p and with a rise time less than 5 ns to channels 1 and 2. Place the feedthrough at the BNC tee Make sure you use the HP 10502A cables to ensure equal cable lengths.

Delay self cal

7 Press the **Delay** softkey, then follow the instructions on the display.

The display will instruct you to connect the signal simultaneously to channels 1 and 2, 1 and 3, 1 and 4, 2 and 4, 2 and 3, and finally to 3 and 4.

8 Set the rear-panel CALIBRATION switch to PROTECTED.

To adjust the low-frequency compensation

In this procedure you adjust the low-frequency compensation adjustment for each channel.

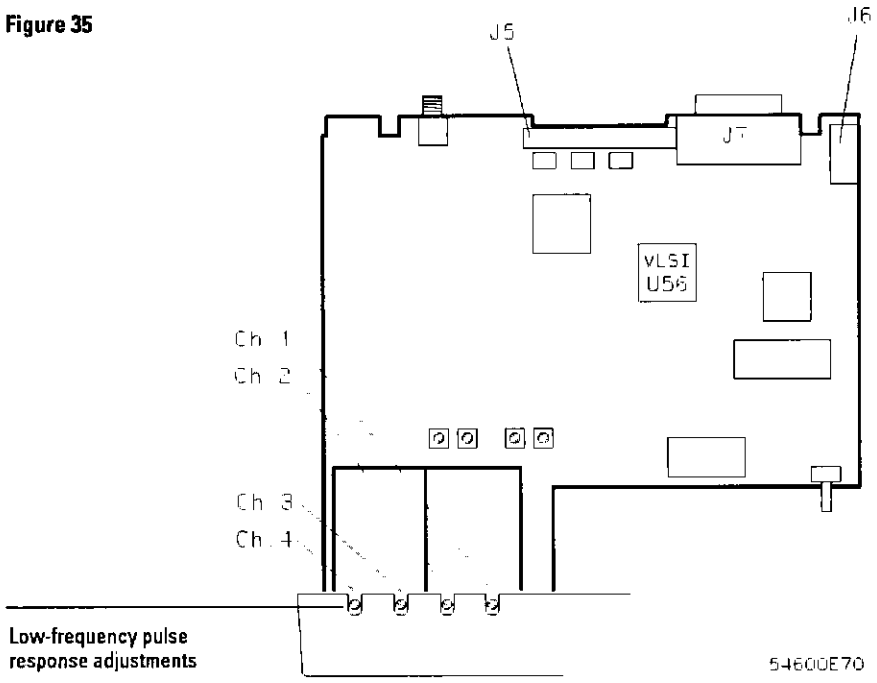
Table 10 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Square wave generator	30 kHz at about 3 Vp-p	HP 8112A
Feedthrough	50 Ω, BNC (m) and (f)	HP10100C
Cable	BNC	HP 10503A

1 Using the BNC cable and 50-Ω feedthrough, connect the square wave generator to channel 1.
2 Adjust the generator for about 30 kHz at about 3 Vp-p.
3 Press Autoscale.
4 Set channel 1 to 500 mV/div.
You must perform this adjustment on the 500 mV range.
5 Adjust the output of the generator until you obtain about 5 to 6 divisions of vertical deflection.

6 Adjust the channel 1 low-frequency compensation adjustment for as flat a pulse top as possible.
7 Repeat steps 1 through 6 for channel 2 (channels 2 to 4 on the HP 54601A and HP 54602A).

Figure 35



To adjust the high-frequency pulse response

In this procedure you adjust the high-frequency pulse response for each channel.

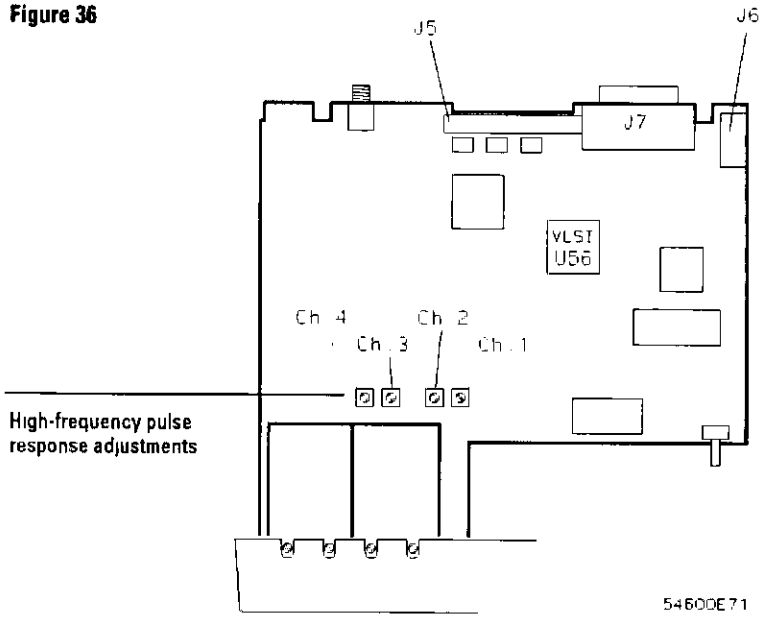
Table 11 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Pulse generator	Rise time < 875 ps	PSPL 1107B TD and PSPL 1110B Driver
Adapter	SMA (f) to BNC (m)	HP 1250-1787
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Connect the pulse generator to channel 1.
2 Press [Autoscale].
3 Change the time base to 10 ns/div.
4 Press [1], then toggle the **vernier** softkey to On.
5 Adjust the Volt/Div until there are about 6 divisions of vertical deflection.

6 Adjust the channel 1 high-frequency response for 1.5 minor division of overshoot (6%).
7 Repeat steps 1 through 6 for channel 2 (channels 2 to 4 on the HP 54601A and HP 54602A).

Figure 36



To adjust the display

The display adjustments are optional and normally do not require adjustment. You should use this procedure only for the few cases when the display is obviously out of adjustment.

Table 12 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Digital multimeter	Accuracy ±0.05%, 1 mV resolution	HP 34401A

1 Connect the digital multimeter to the end of R901 closest to the fuse. See figure 37.
2 Adjust +B for +14.00 V.
3 Press Print/Utility. Press the **Self Test** Softkey, then press the **Display** softkey.
4 Adjust V.HO (vertical hold) for vertical synchronization.
5 Set the intensity control (on the front panel) to mid-range.
6 Adjust Sub Bri (sub bright) to the lowest setting so that the half bright blocks on the display are visible.
7 Increase the intensity control to a comfortable viewing level.
This is usually about 3/4 of its maximum range.

8 Adjust HB Cont (half bright contrast) for the best contrast between the half bright and full bright blocks.

You can readjust Sub Bri, intensity control, and HB Cont to suit your individual preference.

9 Press any key to continue to the next test pattern. Then, adjust H.Hold (horizontal hold) to center the display horizontally.

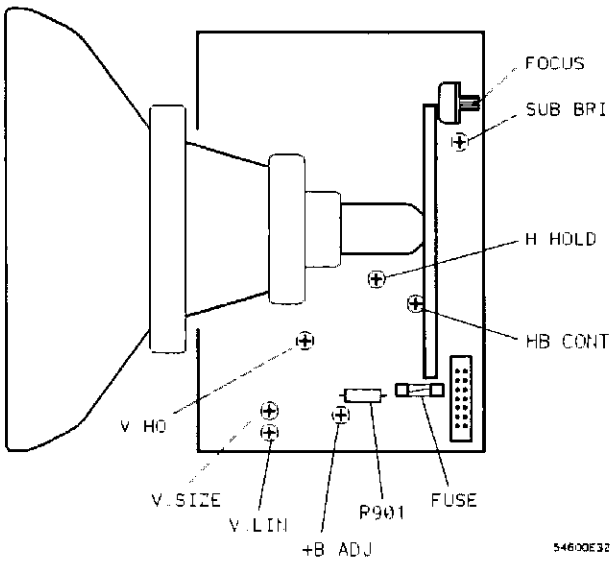
10 Adjust Focus for the best focus.

11 Press any key to continue to the normal display pattern. Then adjust V.Lin (vertical linearity) for equal sizing of all four corner squares.

12 Adjust V.Size (vertical size) to center the display vertically at the maximum allowable size without losing the text.

Adjustments V.Lin and V.Size interact so you may need to readjust sizing and vertical centering of the display.

Figure 37



Troubleshooting the Oscilloscope

The service policy for this instrument is replacement of defective assemblies. The following procedures can help isolate problems to the defective assembly.

WARNING

The maintenance described in this section is performed with power supplied to the oscilloscope and with the protective covers removed. Only trained service personnel who are aware of the hazards involved should perform the maintenance. Whenever possible, perform the procedures with the power cord removed from the oscilloscope. Read the safety summary at the front of this book before proceeding.

CAUTION

Do not disconnect any cables or remove any assemblies with the power applied to the oscilloscope, or damage to the oscilloscope can occur.

The following equipment is needed for troubleshooting the oscilloscope.

Table 13 **Equipment Required**

Equipment	Critical specifications	Recommended model/part
Digital multimeter	Accuracy ±0 05%, 1 mV resolution	HP 34401A
Oscilloscope	100 MHz	HP 54501A
Probe	10:1 division ratio	HP 10432A
Dummy load	Compatible with power supply	HP 54600-66504

To construct your own dummy load

1 Obtain a connector compatible with the connector on the LVPS.

2 Connect the following load resistors to the connector.

+5.1 V requires a 3 A load, 1 7 Ω and 15 W on pin 15, 17, or 19.
+15.75 V requires a 1 3 A load, 12.2 Ω and 20.5 W on pin 11 or 13.
With the fan operating, −15.75 V requires a 0.6 A load, 26.25 Ω and 9.5 W on pin 5 or 7.
Without the fan operating, −15 75 V requires a 0 8 A load, 26.25 Ω and 13 W on pin 5 or 7.

3 Connect the other end of the resistors to ground pins 2, 4, 6, and 8.

To check out the oscilloscope

1 Is there an interface module connected to the oscilloscope?

If yes, do the following steps. If not, go to step 2.

a Turn off the oscilloscope.

b Remove the module.

c Turn on the oscilloscope, then check for the failing symptom.

If the failing symptom disappears, replace the module. If not, go to step 2.

2 Disconnect any external cables from the front panel.

3 Disconnect the power cord, then remove the cover.

4 Connect the power cord, then turn on the oscilloscope.

If the display comes on after a few seconds, (HP logo and copyright text, followed by a graticule with text at top of the display) go to "To check the LVPS," on page 101 If after checking the LVPS the voltages are within the test limits, go to step 8. If not, go to step 6. If the display did not come on, do the steps below.

a Check the intensity knob to see setting to see if its set too low.

b If there is still no display, disconnect the power cord.

c Check all cable connections.

d Go to "To check the LVPS," on page 101.

If the voltages are within the limits go to step 5. If not, go to step 6.

5 Disconnect the display cable, then check the following signals at U56 on the system board. Refer to figure 38.

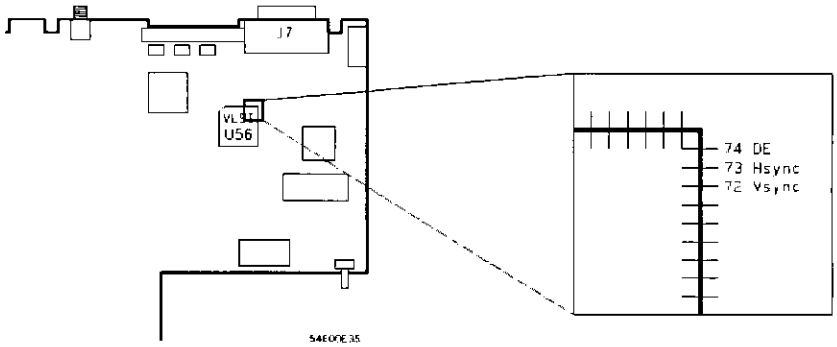
While probing, make sure that you do not short the pins of U56 together. To make the probing easier, use the Emulation Technology 84-pin quad clip (Emulation Technology part number 5402).

Table 14 **Signals at U56**

Pin	Signal	Frequency	Pulse width	Voltage
74	DE	19.72 kHz	38.0 μs	2.6 Vp-p
73	Hsync	19.72 kHz	3.0 μs	5.0 Vp-p
72	Vsync	60.00 Hz	253.5 μs	5.2 Vp-p

If the signals are good, replace the display assembly. If not, replace the system board.

Figure 38



6 Disconnect the LVPS ribbon cable from the display board.

7 Measure the power supply voltages again (steps 1-3).

If the voltages are within the test limits, replace the display assembly. If not, do the steps below.

a Disconnect the power cord.

b Disconnect the ribbon cable from the power supply.

c Connect the dummy load to the power supply connector.

d Connect the power cord, then measure the power supply voltages again (see new tolerances below).

+5.1 V (4.95 V to +5.25 V)
+15.75 V (+15 V to +16.5 V)
−15.75 V (−15 V to −16.5 V)

If the voltages are now within the test limits, replace the system board. If not, replace the power supply.

8 Is the fan running?

If yes, go to "To run the internal self-tests," on page 102. If not, do the steps below.

The LVPS has a thermal cut-out circuit. If the fan is defective, the LVPS shuts down when it gets too hot for safe operation.

a Disconnect the fan cable from the power supply.

b Measure the fan voltage at the connector on the power supply.

If the fan voltage is −8.3 Vdc, replace the fan. If not, replace the power supply.

To check the LVPS

1 Disconnect the power cord, then set the oscilloscope on its side.

2 Connect the negative lead of the multimeter to a ground point on the oscilloscope. Connect the power cord and turn on the oscilloscope.

3 Measure the power supply voltages at L3, L4, and L5 on the system board. See figure 34 on page 87.

+5.1 V ±150 mV (+4.95 V to + 5.25 V)
+15.75 V ±787 mV (+14 96 V to +16.54 V)
−15.75 V ±787 mV (−14 96 V to −16.54 V)

If the +5.1 V measurement is out of the test limits, adjust the +5.1 V adjustment on the power supply The ±15 V supplies are not adjustable and are dependent upon the +5.1 V supply

Blown fuse

If the fuse is blown in the power supply, the power supply is defective. Replace the power supply.

To run the internal self-tests

1 Perform the keyboard test.

a Press Print/Utility .

b Press the **Self Tst** softkey, then press the **Keyboard** softkey.

A pictorial diagram of the front panel will appear on the display.

c Press each key, and notice that when you press a key a corresponding block on the display fills in.

d Rotate the knobs (except the intensity) and notice that an arrow appears on the display that points in the direction you rotate the knob.

e Do all the keys and knobs work?

If yes, Press the **Stop** softkey two or three times (the display indicates how many times), then go to step 2. If not, replace the keyboard and keyboard assembly.

2 Check the output level of the DAC.

a Press the **DAC** softkey

b Connect a multimeter to the rear panel DC CALIBRATOR connector.
The multimeter should read 0 V ±500 μV.

c Press any key to continue.
The multimeter should read 5 V ±10 mV.

d Are the DAC voltages correct?
If yes, press any key to continue. If not, replace the system board.

3 Perform the ROM test

a Press the **ROM** softkey

b Does the display message say **`Test Passed`**?
If yes, press any key to continue. If not, (the display message says **`Test Failed`**) replace the system board.

4 Perform the RAM test.

a Press the **RAM** softkey.

b Does the display message say **Test Passed**?

If yes, press any key to continue. If not, (the display message says **Test Failed**) replace the system board.

5 Perform the display test.

a Press Print/Utility.

b Press the **Self Tst** softkey, then press the **Display** softkey.

c Do the half bright and full bright squares appear?

If yes, continue with the steps below. If not, replace the display.

d Press any key to continue.

e Do squares appear in the four corners?

If yes, the display is good. If not, replace the display.

f Press any key to end the test.

g If you still have the failing symptom, replace the system board.

Replacing Parts in the Oscilloscope

This section contains instructions for removing and ordering replaceable assemblies. Also in this section is a parts list for the assemblies and hardware of the oscilloscope that you can order from Hewlett-Packard.

If you need a component for one of the printed circuit boards, refer to the parts list included with the component information packet for this oscilloscope. For more information on these packets, contact your nearest Hewlett-Packard Sales Office.

Before working on the oscilloscope, read the safety summary at the front of this book.

WARNING Hazardous voltages are on the CRT, power supply, and display sweep board. To avoid electrical shock, disconnect the power cord from the oscilloscope. Wait at least three minutes for the capacitors in the oscilloscope to discharge before you begin disassembling the oscilloscope.

CAUTION Do not replace assemblies with the oscilloscope turned on or damage to the components can occur.

To replace an assembly

Refer to the exploded view of the oscilloscope, figure 41, for details on how the oscilloscope fits together. To install an assembly, follow the instructions in reverse order

You will need the following tools to disassemble the oscilloscope:

- T15 TORX driver to remove the oscilloscope from the cabinet and to remove the fan
- T10 TORX driver to remove the assemblies from the deck.
- Flat-blade screwdriver to remove the optional modules and the pouch.
- 9/16-inch nut driver or wrench to remove BNC nut.

1 Remove the oscilloscope from the cabinet.

a Turn off the oscilloscope and disconnect the power cable.

b If a module is installed, remove it from the oscilloscope.

c Using the T15 TORX driver, remove the two screws from the rear of the cabinet.

d Using your thumbs, gently push on the two rear-panel connectors to slide the oscilloscope out of the cabinet.

2 Remove the faulty assembly.

You can remove any of the following six assemblies: fan, front panel, display, system board, power supply, and keyboard.

Fan

a Disconnect the fan cable from the power supply board.

b Using the T15 TORX driver, remove the three screws that hold the fan to the deck.

Front panel

a Remove the intensity knob by pulling straight out.

b Disconnect the keyboard ribbon cable from the system board.

c Use a screwdriver to release retainer tab A, and your finger to release retainer tab B. See figure 39.

Releasing front panel from deck of intrument

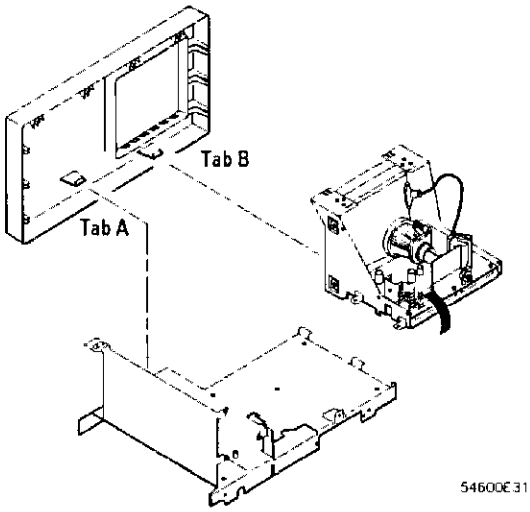
When tab B is released, be careful that the sheet metal tab of front-panel ground input clears the softkey circuit board. The circuit board may be depressed slightly with a screwdriver to avoid damage to the circuit board

d Rotate the front panel out until the bottom clears the rear of the assembly, then lift the front panel to free the hooks on top.

Hint: When installing the front panel, make sure that the power switch shaft is aligned with its mating hole in the front panel.

Hint: The front panel swings in to engage the two retainer tabs Before attempting to engage the retainer tabs, make sure that the six hooks on top of the front panel are fully engaged with their mating holes in the sheet metal

Figure 39



Display

a Remove the front panel.

b Disconnect the ribbon cable and the calibration cable from the display.

c Using the T10 TORX driver, remove the two screws that hold the display to the deck.

Make sure that when you reinstall these screws that you use the correct parts. If longer screws are used, they can short the system board to ground.

d As you lift the display, rotate it off the two tabs on the side of the deck.

System board

a Using the T10 TORX driver, remove the eight screws that hold the system board to the deck (two of the screws are in the attenuator covers).

b Remove the two screws from the rear-panel interface connector and the nut from the rear-panel BNC.

c Disconnect the three ribbon cables and the calibration cable.

d As you remove the system board, rotate the system board so that the BNCs clear the front panel.

Power supply

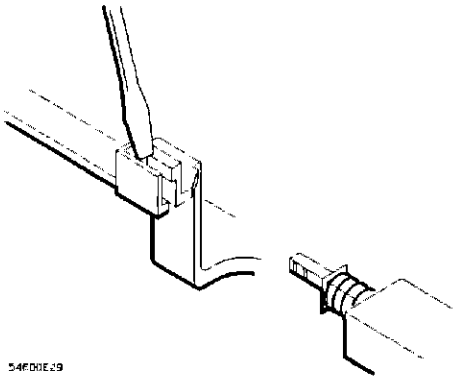
a Remove the fan.

b Disconnect the ground wire (green wire with the yellow stripe) from the deck.

c Disconnect the ribbon cable from the power supply board.

d Use a screw driver to gently unhook the latch that holds the white shaft to the power switch, then disconnect the shaft from the power switch. After you disconnect the shaft, make sure you position it in the recess along the side of the display bracket.

Figure 40



e Using the T10 TORX driver, remove the screw holding the power supply board to the deck.

f Slide the power supply board towards the front panel about a half an inch. Slip the keyhole slots on the power supply board off of the pins on the deck.

Keyboard

a Remove the front panel.

b Remove all the knobs by pulling straight out.

c Flex the bezel of the front panel to unsnap the small keyboard under the display opening.

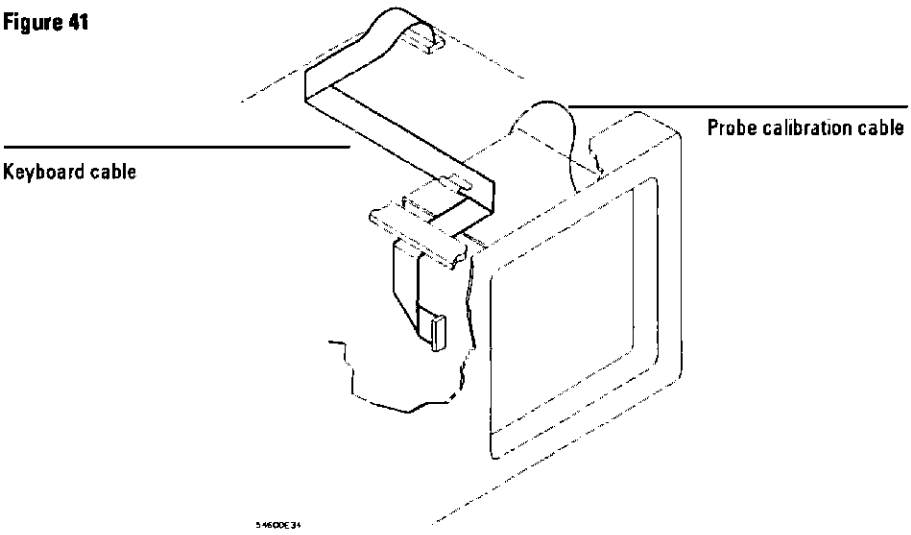
d Using the T10 TORX driver, remove the three screws from the large keyboard.

Make sure that when you reinstall these screws that you use the correct parts. If longer screws are used, they can damage the front-panel label.

e Press down on the top of the keyboard, and rotate the bottom of the keyboard out.

When installing the keyboard, make sure that the probe calibration cable is kept away from the keyboard cable or noise can occur in the probe adjust signal. See figure 41 for positioning the keyboard cable.

Figure 41



To remove the handle

- Rotate the handle down until it is just past the last detent position (about 1/2 inch before the handle touches the bottom of the oscilloscope), then pull the sides of the handle out of the cabinet.

To order a replacement part

The system board is part of an exchange program with Hewlett-Packard. The exchange program allows you to exchange a faulty assembly with one that has been repaired and performance verified by Hewlett-Packard.

After you receive the exchange assembly, return the defective assembly to Hewlett-Packard. A United States customer has 30 days to return the defective assembly. If you do not return the faulty assembly within the 30 days, Hewlett-Packard will charge you an additional amount. This amount is the difference in price between a new assembly and that of the exchange assembly. For orders not originating in the United States, contact your nearest Hewlett-Packard Sales Office for information

- To order a part in the material list, quote the Hewlett-Packard part number, indicate the quantity desired, and address the order to your nearest Hewlett-Packard Sales Office.

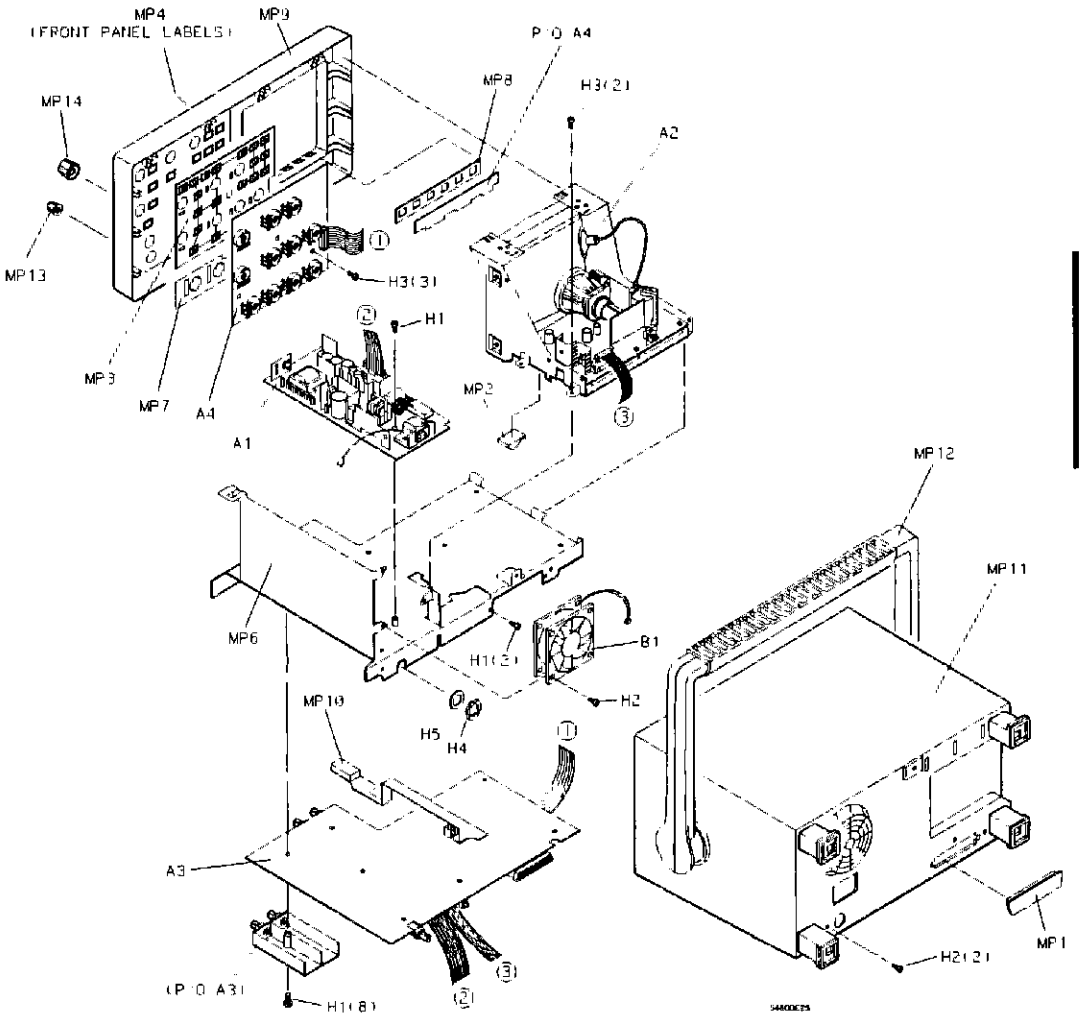
- To order a part not listed in the material list, include the model number and serial number of the oscilloscope, a description of the part (including its function), and the number of parts required. Address the order to your nearest Hewlett-Packard Sales Office.

- To order using the direct mail order system, contact your nearest Hewlett-Packard Sales office.

  Within the USA, Hewlett-Packard can supply parts through a direct mail order system. The advantages to the system are, direct ordering and shipment from the HP Parts Center in Mountain View, California. There is no maximum or minimum on any mail order. (There is a minimum amount for parts ordered through a local Hewlett Packard Sales Office when the orders require billing and invoicing.) Transportation costs are prepaid (there is a small handling charge for each order) and no invoices.

  In order for Hewlett-Packard to provide these advantages, a check or money order must accompany each order. Mail order forms and specific ordering information are available through your local Hewlett-Packard Sales Office. Addresses and telephone numbers are located in a separate document shipped with the instrument.

Figure 42



Exploded view of oscilloscope showing reference designators.

Table 15 **HP 54600A and HP 54601A Replaceable Parts**

Reference Designator	HP Part Number	Qty	Description
A1	0950-2125	1	Power supply assembly
A2	2090-0244	1	Display assembly
A3	54600-66501	1	System board (HP 54600A only)
A3	54600-69501		Exchange system board (HP 54600A only)
A3	54601-66501	1	System board (HP 54601A only)
A3	54601-69501		Exchange system board (HP 54601A only)
A3	54602-66501	1	System board (HP 54602A only)
A3	54602-69501		Exchange system board (HP 54602A only)
A4	54600-66502	1	Keyboard (HP 54600A only)
A4	54601-66502	1	Keyboard (HP 54601A and HP 54602A only)
B1	3160-0619	1	Fan
H1	0515-0372	11	Machine screw M3 X 8
H2	0515-0380	5	Machine screw M4 X 10
H3	0515-0430	5	Machine screw M3 X 6
H4	1250-2075	1	RF connector nut, 0.5 inch
H5	2190-0068	1	Lock washer
MP1	1251-2485	1	Connector dust cover
MP2	1400-1581	1	Cable clamp
MP3	54600-41901	1	Large keypad (HP 54600A only)
MP3	54601-41901	1	Large keypad (HP 54601A only)
MP4	54600-94301	1	Front-panel label (HP 54600A only)
MP4	54601-94301	1	Front-panel label (HP 54601A only)
MP4	54602-94301	1	Front-panel label - China (HP 54602A only)
MP4	54602-94302	1	Front-panel label (HP 54602A only)
MP5	54600-94303	1	Handle Label (HP 54600A only)
MP5	54601-94303	1	Handle Label (HP 54601A only)
MP5	54602-94303	1	Handle Label (HP 54602A only)
MP6	54601-00101	1	Deck
MP7	54601-07101	1	EMI gasket

Reference Designator	HP Part Number	Qty	Description
MP8	54601-41902	1	Small rubber keypad
MP9	54601-42201	1	Front panel
MP10	54601-43701	1	Power-switch shaft
MP11	54601-64401	1	Cabinet (comes with handle and feet installed)
MP12	54601-44901	1	Handle
MP13	54601-47401	8	Small knob (HP 54600A has 6)
MP14	54601-47402	3	Large knob
MP15	54601-47403	1	Intensity knob
W1	8120-1521	1	Standard power cord
W1	8120-1703		Power cord option 900, United Kingdom
W1	8120-0696		Power cord option 901, Australia
W1	8120-1692		Power cord option 902, Europe
W1	8120-0698		Power cord option 904, 250 V, USA/Canada
W1	8120-2296		Power cord option 906, Switzerland
W1	8120-2957		Power cord option 912, Denmark
W1	8120-4600		Power cord option 917, Africa
W1	8120-4754		Power cord option 918, Japan
	Option 101		**Accessory pouch and front-panel cover.**
	5041-9411		Pouch
	54601-44101		Front-panel cover

Accessory replacement boards

54650-66502	HP-IB interface module
54651-66502	RS-232-C interface module
54652-66501	Parallel output interface module
54654-66501	Training signal board

Attenuator covers replacement parts (these are a part of the A3 system board)

54600-62001	External trigger attenuator cover (used on HP 54600A only)
54601-62001	Channel attenuator cover (one used on HP 54600A, two used on HP 54601A and HP 54602A)
0624-0729	Screw that holds attenuator cover to system board
54601-09101	BNC contact spring, one per BNC

4

Performance Characteristics

Performance Characteristics

The performance characteristics describe the typical performance of the oscilloscope. You will notice that some of the characteristics are marked as tested, these are values that you can verify with the performance tests under "Verifying Oscilloscope Performance," on page 67.

Vertical System

All channels

Bandwidth[1]:
- dc to 100 MHz −3 dB (HP 54600A & HP 54601A)
- dc to 150 MHz −3 dB (channels 1 & 2, HP 54602A)
- dc to 250 MHz −3 dB (channels 3 & 4, HP 54602A)
- ac coupled, 10 Hz to 100 MHz −3 dB (HP 54600A & HP 54601A)
- ac coupled, 10 Hz to 150 MHz −3 dB (channels 1 & 2, HP 54602A)

Rise time
- 3.5 ns (calculated, HP 54600A & HP 54601A)
- <2.33 ns (calculated, channels 1 & 2, HP 54602A)
- <1.4 ns (calculated, channels 3 & 4, HP 54602A)

Dynamic range: ±32 V or ±8 divisions, whichever is less

Math functions: Channel 1 + or − channel 2

Input resistance: 1 MΩ

Input capacitance: ≈13 pf

⚠ Maximum input voltage: 400 V (dc + peak ac)

1 Tested, see "To verify bandwidth," on page 72.

Channels 1 and 2

Range: 2 mV/div to 5 V/div
Accuracy[1]: ±1.5%
Vernier[1]: Fully calibrated, accuracy about ±3%
Cursor accuracy[1, 2, 3]:
  Single cursor accuracy: vertical accuracy ±1 2% of full scale ±0.5% of position value
  Dual cursor accuracy: vertical accuracy ±0.4% of full scale
Bandwidth limit: ≈20 MHz
Coupling: Ground, ac, and dc
Inversion: Channel 1 and channel 2
CMRR (common mode rejection ratio): ≈ 20 dB at 50 MHz

Channels 3 and 4 (HP 54601A & HP 54602A only)

Range: 0.1 V/div and 0.5 V/div ranges
Accuracy[1]: ±1.5%
Coupling: Ground and dc

1 When the temperature is within ±10 °C from the calibration temperature
2 Use a full scale of 80 mV for 2 mV/div and 5 mV/div ranges
3 Tested, see "To verify voltage measurement accuracy," on page 69.

Horizontal System

Sweep speeds: 5 s/div to 2 ns/div main and delayed
Accuracy: ±0.01%
Vernier, Accuracy ±0.05%
Horizontal resolution: 100 ps
Cursor accuracy[1,2]: (Δt and 1/Δt) ±0.01% ±0.2% of full scale ±200 ps
Delay jitter: 10 ppm
Pretrigger delay (negative time): ≥10 divisions
Posttrigger delay (from trigger point to start of sweep): at least 2560 divisions or 50 ms. Not to exceed 100 s.
Delayed sweep operation

Main sweep	Delayed sweep
5 s/div to 10 ms/div	up to 200 times main sweep
5 ms/div and faster	up to 2 ns/div

1 Use full scale of 50 ns on 2 ns/div range.
2 Tested, see "To verify horizontal Δt and 1/Δt accuracy," on page 78.

Trigger System

Internal trigger

Sensitivity[1]:
- dc to 25 MHz 0.35 div or 3.5 mV (all channels on all models)
- dc to 100 MHz 1 div or 10 mV (all channels on HP 54600A & HP 54601A)
- dc to 150 MHz 1 div or 10 mV (channels 1 & 2 on HP 54602A)
- dc to 250 MHz 1 div or 10 mV (channels 3 & 4 on HP 54602A)

Sources:
- Channels 1 to 4 and line on HP 54601A & HP 54602A
- Channels 1, 2, line, and external on HP 54600A

Coupling: ac, dc, LF reject, HF reject, and noise reject
- LF reject and HF reject −3 dB at ≈50 kHz

Modes: Auto, Autolevel, Normal, Single, and TV
TV triggering: Available on channels 1 and 2 only
TV line and field: 0.5 division of composite sync for stable display
Holdoff: Adjustable from 200 ns to ≈13 s

External trigger (available on HP 54600A only)

Range: ±18 V
Sensitivity[1]:
- dc to 25 MHz 50 mV
- dc to 100 MHz 100 mV

Coupling: dc, HF reject, and noise reject
Input resistance: 1 MΩ
Input capacitance: ≈13 pf
⚠ Maximum input voltage: 400 V (dc + peak ac)

1 Tested, see "To verify trigger sensitivity," on page 81

XY Operation

Z Blanking: TTL high blanks trace
Bandwidths: X and Y same as vertical system
Phase difference: ±3 degrees at 100 kHz

Display System

Display: 7-inch raster CRT
Resolution: 255 vertical by 500 horizontal points
Controls: Front-panel intensity control
Graticule: 8 × 10 grid or frame
Autostore: Autostore saves previous sweeps in half bright display and the most recent sweep in full bright display.

Acquisition System

Maximum sample rate: 20 MSa/s
Resolution: 8 bits
Simultaneous channels: Channels 1 and 2 or channels 3 and 4
Record length: 4,000 points (2,000 single shot)
Maximum update rate: 1,000,000 points/s
Single-shot bandwidth: 2 MHz single channel, 1 MHz dual channel
Peak detect: 50 ns glitch capture (100 ns dual channel) from 5 s/div to 50 µs/div
Average: Number of averages selectable at 8, 64, and 256

Advanced Functions

Automatic measurements (measurements are continuously updated)
- Voltage: Vavg, Vrms, Vp-p, Vtop, Vbase, Vmin, Vmax
- Time: Frequency, period, + width, − width, duty cycle, rise time, and fall time

Cursors: Manually or automatically placed

Setup functions:
- Autoscale: Sets vertical and horizontal deflections and trigger level for signals with a frequency ≥50 Hz, duty cycle >1% and voltage level
  - channels 1 and 2 >20 mVp-p
  - channels 3 and 4 >100 mVp-p
  - external trigger (HP 54600A only) >100 mVp-p
- Save/Recall: 16 front-panel setups
- Trace memory: Two volatile pixel memories

Power Requirements

Line voltage range: 100 Vac to 240 Vac
Line voltage selection: Automatic
Line frequency: 45 Hz to 440 Hz
Maximum power consumption: 220 VA

General

Environmental characteristics

The instrument meets or exceeds the environmental requirements of MIL-T-28800D for Type III, Class 3, Style D equipment as described below.

Ambient temperature: (Tested to MIL-T-28800D paragraphs 4.5.5.13 option 2 and 4.5.5.14)
- Operating: −10 °C to +55 °C (+14 °F to +131 °F)
- Nonoperating: −51 °C to +71 °C (−60 °F to +160 °F)

Humidity: (tested to Hewlett-Packard environmental specification section 758 paragraphs 4.0, 4.1, and 4.2 for class B-1 products)
- Operating: 95% relative humidity at +40 °C (+104 °F) for 24 hours
- Nonoperating: 90% relative humidity at +65 °C (+149 °F) for 24 hours

Altitude: (Tested to MIL-T-28800E paragraph 4.5.5.2)
- Operating: to 4,500 m (15,000 ft)
- Nonoperating: to 15,000 m (50,000 ft)

EMI

EMI (commercial) FTZ 1046 Class B

EMI Meets the requirements in accordance with MIL-T-28800,
paragraph 3.8.3 table XII, and MIL-STD-461C
CE01 Part 2 narrow band requirements up to 15 kHz
CE03 Part 4
CE07 full limits
CS01: Part 2
CS02: Part 2
CS06: Part 5 limited to 300 V
RE01 Parts 5 and 6 measured at 12 inches, 15 dB relaxation to 20 kHz, and
exceptioned from 20 kHz to 50 kHz.
RE02 Part 2 (limited to 1 GHz) Full limits of class A1c and A1f,
with option 002 installed
without option 002 installed 10 dB relaxation, 14 kHz to 100 kHz
RS02 Part 2, Part I Exceptioned
RS02 Part 2, Part II Exceptioned
RS03: Part 2, limited to 1 V/meter from 14 kHz to 1 GHz
(with option 001 installed) Slight trace shift from 80 MHz to 200 MHz

Vibration

Operating: 15 minutes along each of the 3 major axes; 0.025 inch p-p
displacement, 10 Hz to 55 Hz in one-minute cycles. Held for 10 minutes
at 55 Hz (4 g at 55 Hz).

Shock

Operating: 30 g, 1/2 sine, 11 ms duration, 3 shocks per axis along major axis.
Total of 18 shocks.

Physical characteristics

Size (excluding handle)
Height 172 mm (6.8 in)
Width 322 mm (12.7 in)
Depth 317 mm (12.5 in)
Weight: 6 2 kg (14lbs)

Product Regulations

Safety IEC 348
UL 1244
CSA-C22 2 No 231 (Series M-89)

EMC This Product meets the requirement of the European Communities (EC) EMC Directive 89/336/EEC.

Emissions EN55011/CISPR 11 (ISM, Group 1, Class A equipment)
SABS RAA Act No. 24 (1990)

Immunity

EN50082-1	Code[1]	Notes[2]
IEC 801-2 (ESD) 8kV AD	1	
IEC 801-3 (Rad.) 3 V/m	1	
IEC 801-4 (EFT) 1kV	1	

[1] Performance Codes
1 PASS - Normal operation, no effect.
2 PASS - Temporary degradation, self recoverable.
3 PASS - Temporary degradation, operator intervention required.
4 FAIL - Not recoverable, component damage

[2] Notes:
(None)

Sound Pressure Level Less than 60 dBA

Glossary

Auto A trigger mode that produces a baseline display if the trigger conditions are not met. If the trigger frequency is less than 25 Hz, even if the level and slope conditions are met, a free running display will result.

Auto Level The oscilloscope sets the trigger point to the 50% amplitude point on the displayed waveform. If there is no signal present, a baseline is displayed.

Autoscale Front-panel key that automatically sets up the oscilloscope to display a signal.

Autostore displays the stored waveforms in half bright, and the most recent trace is displayed in full bright.

Baseline Free running trace on the display when no signal is applied and the trigger mode is set to auto or auto level.

BW Lim (Bandwidth Limit) Limits the displayed bandwidth of the selected channel to 20 MHz, and is available for channels 1 and 2 only. This feature is useful for viewing noisy signals.

Coupling (Coupling) For the channels, it changes the input coupling. Channels 1 and 2 allow dc, ac, or ground, while channels 3 and 4 allow dc or ground. In the trigger menu, it toggles between dc and ac for trigger coupling.

Cursors Horizontal and vertical markers used for making custom voltage and time measurements.

Delay In main sweep, the delay knob moves the sweep horizontally, and indicates how far the time reference is from the trigger point. In delayed sweep the delay knob moves the starting point of the portion of the main sweep to be expanded by the delayed sweep.

Delayed Gives an expanded view of the main sweep

Display Allows selection of either normal, peak detect, or averaged display modes.

Erase Clears the display.

External Trigger Is available only on the two channel oscilloscope. Nonviewable input that is usable as a trigger source only

Field 1 Triggers on the field 1 portion of the video signal.

Field 2 Triggers on the field 2 portion of the video signal.

HF Reject (high frequency reject) Adds a low pass filter with a 3 dB point at 50 KHz to the trigger path.

Holdoff Keeps the trigger from rearming for an amount of time set by the holdoff knob.

Internal Trigger The oscilloscope triggers from a channel input that you choose

Invert Invert shifts the displayed waveform 180 degree, and is available for channels 1 and 2 only. When the oscilloscope is triggered on the signal to be inverted, the trigger is also inverted.

Level Front-panel knob that changes the trigger level.

LF Reject (low frequency reject) Adds a high pass filter with a 3 dB point at 50 KHz to the trigger path.

Line In TV trigger mode, the oscilloscope triggers on the TV line sync pulses. As a trigger source, the oscilloscope triggers off of the power line frequency.

Main Sets the oscilloscope to a volts vs time display that displays the main time base sweep.

Mode Allows you to select one of five trigger modes, Auto level, Auto, Normal, Single, TV.

Noise Rej (noise reject) Decreases the trigger sensitivity to reduce the triggering on signal noise.

Normal If a trigger signal is present and the trigger conditions are met, a waveform is displayed. If there is no trigger signal, the oscilloscope does not trigger and the display is not updated.

Peak Det (peak detect) Allows detection of signal extremes as the sample rate is decreased in the 5 s to 50 ms/div time base settings.

Polarity Selects either positive or negative TV sync pulses.

Position Knob that moves the signal vertically on the display.

Print/Utility Allows access to the module menus and service menus.

Probe Allows selection of 1, 10, or 100 to match a probe's division ratio so that the vertical scaling and voltage measurements reflect the actual voltage levels at the tip of the probe.

Recall Recalls a selected front-panel setup that you saved to one of 16 memory location. Memory selection is with either a softkey or the knob closest to the Cursors front-panel key.

Recall Setup Recalls the front-panel setup that was saved with a waveform.

Run The oscilloscope acquires data and displays the most recent trace.

Save Saves the current front-panel setup to one of the possible 16 memory locations. Memory selection is with either a softkey or the knob closest to the Cursors front-panel key.

Setup Allows access to front-panel setup keys.

Single (single shot) The oscilloscope triggers once when the trigger conditions are met. The oscilloscope must be rearmed before the oscilloscope retriggers by pressing either the Run or Autostore front-panel keys

Slope/Coupling Allows access to the trigger slope and input coupling menus.

Slope Selects either the rising or falling edge of the signal to trigger the oscilloscope.

Source Allows you to select a trigger source

Stop Freezes the display.

Time Allows access to the automatic time measurement keys.

Time/Div Changes the time base in a 1-2-5 step sequence from 2 ns to 5 s.

Time Ref Lft Cntr (time reference left or center) Sets the time reference to either one graticule in from the left edge of the display or to center of the display.

Trace Allows access to the trace storage keys.

Trace Mem (trace memory) One of two pixel memory locations used for storing traces.

TV Allows access to the TV slope and trigger coupling keys.

Vernier Vernier allows a calibrated fine adjustment with the channel 1 and 2 Volts/Div knob, and the time base Time/Div knob.

Voltage Allows access to the automatic voltage measurement keys.

Volts/Div Changes the vertical scaling in a 1-2-5 step sequence from 2 mV to 5 V.

XY Changes the display to a volts versus volts display.

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DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company

Manufacturer's Address: 1900 Garden of the Gods Road
Colorado Springs , CO 80901
U.S.A.

declares, that the product

Product Name: Oscilloscope

Model Number(s): HP 54600A/54601A/54602A

Product Options: All

conforms to the following product specifications:

Safety: IEC 348 / HD 401
UL 1244
CSA - C22.2 No. 231 (Series M-89)

EMC: CISPR 11:1990 /EN 55011 (1991): Group 1 Class A
IEC 801-2:1991 /EN 50082-1 (1992): 8 kV AD
IEC 801-3:1984 /EN 50082-1 (1992): 3 V/m
IEC 801-4:1988 /EN 50082-1 (1992): 1 kV

Supplementary Information:

Colorado Springs, June 10, 1992

John Strathman, Quality Manager

European Contact Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ / Standards Europe, Herrenberger Straße 130, D-7030 Boblingen (FAX: +49-7031-144195)

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Complete product warranty information is given at the end of this manual.

Safety

This apparatus has been designed and tested in accordance with IEC Publication 348, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warning

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock of fire hazard.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- If you energize this instrument by an auto transformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Use caution when exposing or handling the CRT. Handling or replacing the CRT shall be done only by qualified maintenance personnel.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

Hazardous voltage symbol.

Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

WARNING

The Warning sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a Warning sign until the indicated conditions are fully understood and met.

CAUTION

The Caution sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a Caution symbol until the indicated conditions are fully understood or met.

Hewlett-Packard
P.O. Box 2197
1900 Garden of the Gods Road
Colorado Springs, CO 80901

Product Warranty

This Hewlett-Packard product has a warranty against defects in material and workmanship for a period of three years from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products that prove to be defective

For warranty service or repair, this product must be returned to a service facility designated by Hewlett-Packard.

For products returned to Hewlett-Packard for warranty service, the Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country.

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The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

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Certification

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

About this edition

This is the first edition of the *HP 54600-Series Oscilloscope User and Service Guide*

Publication number
54600-90915

Printed in USA

Edition dates are as follows:

First edition, June 1992

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by you. The dates on the title page change only when a new edition is published.

A software or firmware code may be printed before the date. This code indicates the version level of the software or firmware of this product at the time the manual or update was issued. Many product updates do not require manual changes, and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

The following list of pages gives the date of the current edition and of any changed pages to that edition.

All pages original edition

New HP 54602A Oscilloscope

This manual also applies to the new HP 54602A Oscilloscope. The HP 54602A is identical to the 4-channel HP 54601A oscilloscope with the following exceptions:

Specification changes

Vertical System:

Bandwidth:
- dc to 150 MHz −3 dB (channels 1 & 2)
- dc to 250 MHz −3 dB (channels 3 & 4)
- ac coupled, 10 Hz to 150 MHz −3 dB (channel 1 & 2)

Rise time
- <2.33 ns (calculated, channels 1 & 2)
- <1.4 ns (calculated, channels 3 & 4)

Trigger System

Internal trigger sensitivity:

dc to 25 MHz	0.35 div or 3.5 mV (all channels)
dc to 150 MHz	1 div or 10 mV (channels 1 & 2)
dc to 250 MHz	1 div or 10 mV (channels 3 & 4)

Operation changes

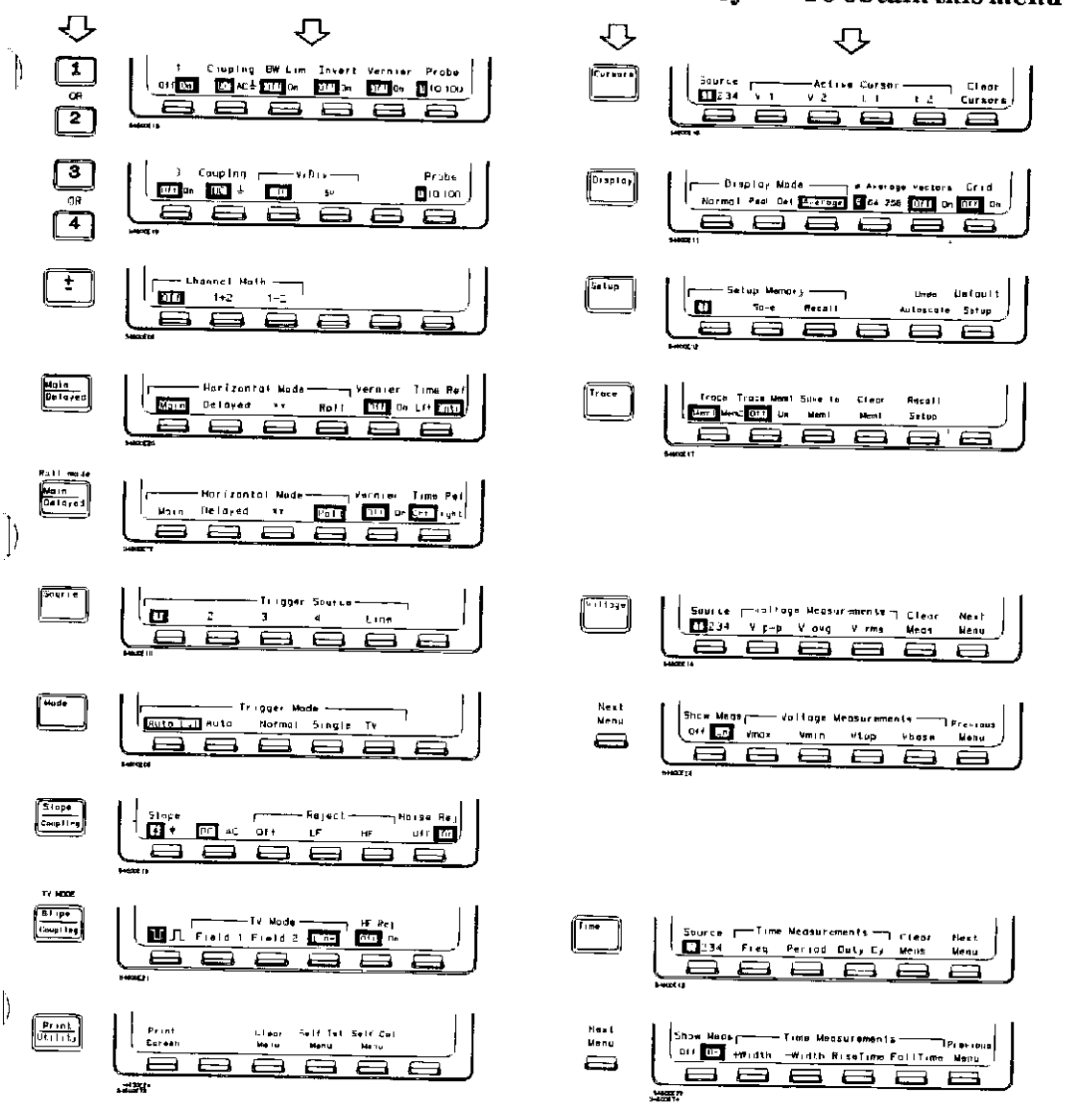
TV Trigger

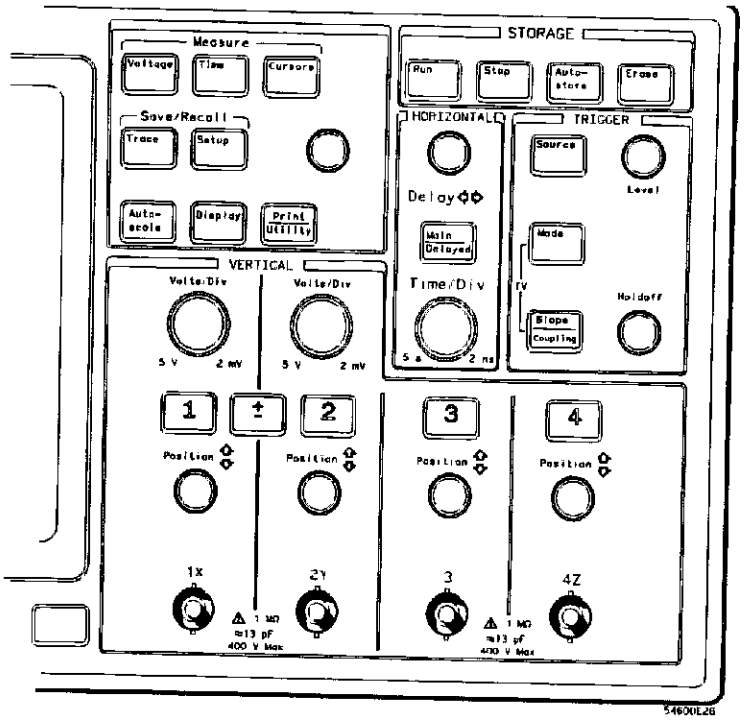
The HP 54602A can trigger on the vertical sync pulse in both TV fields at the same time. This allows you to view noninterlaced video signals which are common in today's computer monitors To trigger on both sync pulses, press **Field 1** and **Field 2** at the same time.

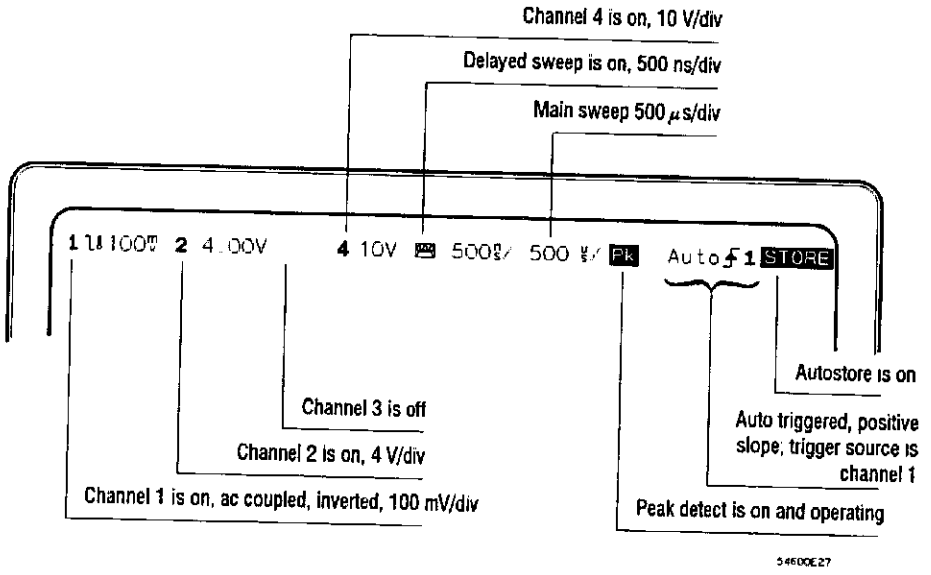
New feature (all models)

Vector Display Mode (all HP 54600-series Oscilloscopes)

The new vector display mode will draw vectors between the sample points on the display when the oscilloscope is stopped or is in single shot mode. On waveforms where only a few samples are displayed that represent the waveform, you may find it easier to view the waveform when vectors is turned on. **Vectors On/Off** is selected in the Display menu.


Press this key
To obtain this menu
Press this key
To obtain this menu
1
OR
2
3
OR
4
±
Main Delayed
Main Delayed
Source
Mode
Slope Coupling
TV MODE
Slope Coupling
Print Utility
Cursors
Display
Setup
Trace
Voltage
Next Menu
Time
Next Menu
Coupling
BW Lim
Invert
Vernier
Probe
Channel Math
Horizontal Mode
Vernier
Time Ref
Trigger Source
Trigger Mode
Slope
Reject
Noise Rej
TV Mode
HF Rej
Print Screen
Clear Menu
Self Test
Self Cal
Active Cursor
Clear Cursors
Display Mode
Average Vectors
Grid
Setup Memory
Undo
Autoscale
Default Setup
Trace
Trace Mem
Save to Mem
Clear Mem
Recall Setup
Voltage Measurements
Clear Meas
Next Menu
Show Meas
Previous Menu
Vmax
Vmin
Vtop
Vbase
Time Measurements
Freq
Period
Duty Cy
+Width
-Width
Risetime
Falltime


Measure
Voltage
Time
Cursors
Save/Recall
Trace
Setup
Auto-scale
Display
Print Utility
STORAGE
Run
Stop
Auto-store
Erase
HORIZONTAL
Delay
Main Delayed
Time/Div
TRIGGER
Source
Level
Mode
Holdoff
Slope Coupling
VERTICAL
Volts/Div
Position
1
2
3
4
54600E26


Channel 4 is on, 10 V/div
Delayed sweep is on, 500 ns/div
Main sweep 500 µs/div
1 100mV 2 4.00V 4 10V 500ns/ 500 µs/ Pk Auto 1 STORE
Autostore is on
Auto triggered, positive slope; trigger source is channel 1
Peak detect is on and operating
Channel 3 is off
Channel 2 is on, 4 V/div
Channel 1 is on, ac coupled, inverted, 100 mV/div
54600E27

About this new oscilloscope:

Here is an oscilloscope that gives you all the benefits of digital features without giving up the advantages of analog. This new oscilloscope is all-digital, not a hybrid, which means you will have all the advantages of digital features, such as:

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- One-button storage
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- Remote programming
- Hardcopy output to printers and plotters
- Unattended signal monitoring
- Benchtop pass/fail testing

At the same time, this oscilloscope offers an analog-like, highly interactive display.

This powerful combination of digital power with analog look and feel will greatly enhance your ability to solve tough problems. Waveforms that you cannot see on analog oscilloscopes are conveniently displayed and measured on the HP 54600-series oscilloscopes.

Errata

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HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

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Agilent Technologies

Programmer's Guide for QuickC and QuickBASIC

Publication Number 54600-90912
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HP 54600A and HP 54601A Oscilloscopes

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Introduction

Today's research and manufacturing engineers are being pressured to improve productivity while reducing costs. To remain competitive in the fast-paced electronics marketplace, engineers must reduce product design cycles. Testing the finished product must be accomplished in the shortest possible time and in the most repeatable manner.

The low cost of the personal computer, teamed with the power of custom software, allow engineers to use oscilloscopes to speed the development and analysis of their circuitry.

About This Book

This guide describes how an HP Vectra or an IBM PC/XT/AT personal computer is programmed to converse with the HP 54600A series of oscilloscopes via the HP-IB IEEE 488 2 interface. A sample program is provided to get you started and to overcome some of the hurdles a first-time programmer faces. The guide is not intended to be all inclusive. That is, it is not a tutorial on HP-IB, programming a personal computer, or the full HP-IB capability of the oscilloscope.

The HP-IB interface card used is the HP 82335. The earlier version card (HP 82990A) can be used if the most recent HP 82335 drivers are installed. If the most recent drivers are not used, some commands like the IOENTERAB, will not function.

A sample program is written in both Microsoft QuickC (version 2 5) and Microsoft QuickBASIC (version 4.5) . Each program is modular, with explanations about each module.

The computer configuration must be set up as specified in both the HP-IB manual ("Using the HP-IB Interface and Command Library") and the Microsoft Language manuals. All drivers and libraries must be installed as specified in those manuals.

If you are familiar with programming oscilloscopes over the IEEE 488 bus, you may wish to skip to the "Getting Started" Section The next two sections discuss introductory programming material and the three fundamental parts of a program.

References

This book provides more information than the standard documentation for the HP 54600A series digitizing oscilloscopes. It is not all-inclusive and is meant to be used with knowledge contained in the following references:

HP-IB Reference Manuals -- *Tutorial Description of the Hewlett Packard Interface Bus* HP Part Number 5021-1927 and *Using the HP-IB Interface and Command Library* HP Part Number 82335-90001.

HP 54600A and HP 54601A Digitizing Oscilloscope *Programmer's Guide* HP Part Number 54600-90909.

Microsoft QuickC Manuals: *C for Yourself* (version 2 5), *Up and Running* (version 2.5), and *Tool Kit* (version 2.5)

Microsoft QuickBASIC Manuals for IBM Personal Computers and Compatibles *Learning to Use Microsoft QuickBASIC* (version 4.5), *Programming in BASIC* (version 4.5), and *Microsoft QuickBASIC BASIC Language Reference* (version 4.5) .

Programming the Oscilloscope

Typically, there are several basic operations that an engineer will want a computer and oscilloscope to do in a programming environment:

- set up the oscilloscope,
- make measurements,
- get data (measurements, waveform data, configurations) from the oscilloscope for analysis by the computer ,and
- send information (waveform data or configurations) to the oscilloscope.

Very complicated tasks can be accomplished using the flexibility of the computer and the combination of these four basic functions.

To be successful in merging the oscilloscope and computer, you first need to make the measurement using the front panel. The process over the bus will be much the same as that from the front panel.

Many front panel and programming operations are similar:

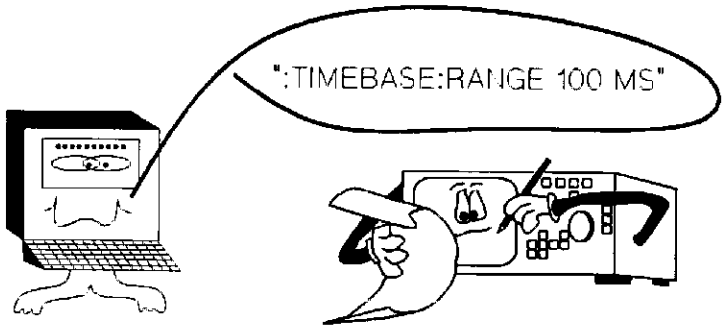
Front Panel:	push a key, use the menus
Programming:	send a command, use the subsystems

Several front panel and programming operations are different:

Front Panel:	set V/div, see waveform
Programming:	send the full scale range, get data that can be plotted on computer screen or converted to volts/time

Computers communicate with the oscilloscope by sending and receiving messages over the bus using input/output (I/O) statements provided in the programming language.

COMMUNICATING WITH THE SCOPE



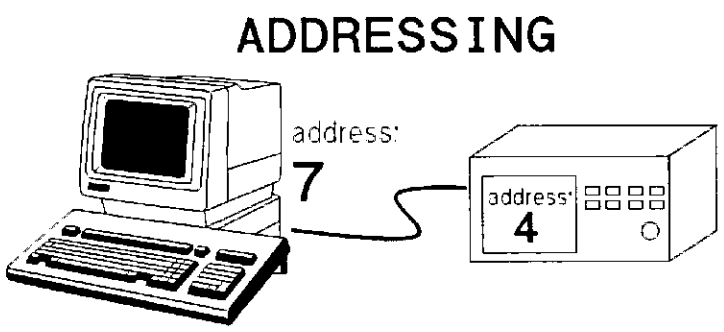
Messages for programming the oscilloscope appear as ASCII character strings embedded inside I/O program statements. Each message consists of a device address, a program message, and a terminator. The address uniquely identifies one of the instruments on the bus while the program message specifies the action to be taken by that instrument.

Device Address

The address is composed of two parts:

- Interface Select Code (ISC)
- instrument address

Each HP-IB interface card has its own ISC address set on the card. This address is used to direct commands and communications to the proper interface. Each instrument on the HP-IB bus must have a unique address that is between decimal 00 and 30. The instrument address must be set in the HP-IB menu from the front panel, as described in "Getting Started".



DEVICE ADDRESS = (Interface * 100) + Instrument

= (7 * 100) + 4 = 704

QuickBASIC:	QuickC:
Isc& = 7	DEFINE Isc 7L
Scope& = 704	DEFINE SCOPE 704L

(must be long variables)

Message Basics: Command/Query

There are two basic forms of messages· commands and queries.

The format of the command and query are the same, but the query has a question mark (?) attached to the command message.

The function of the command and query are vastly different.

- Commands are used to set up the oscilloscope or to specify that an action be taken.
- Queries are used to find out how the oscilloscope is set up or to get results from the oscilloscope.

A query causes the oscilloscope to put data into an output buffer of the oscilloscope. This data must be read from the oscilloscope into the computer using an input statement. If the data is not read from the oscilloscope, and a new command or query is sent to the oscilloscope, the error message "QUERY INTERRUPTED" is displayed.

Examples of Commands:

```
":TIMEBASE:RANGE 5E-6"
```

Sets the timebase range to 5 us (500 ms/div) .

```
":AUTOSCALE"
```

Automatically sets up the oscilloscope to display a signal.

Examples of Queries:

```
":TIMEBASE:RANGE?"
```

Queries the oscilloscope for its current time base range. The oscilloscope puts the result into the output buffer, and the result must be read from the oscilloscope using an input statement.

```
":MEASURE:VPP?"
```

Queries the oscilloscope for a volt peak-to-peak measurement. The oscilloscope puts the result into the output buffer, and the result must be read from the oscilloscope using an input statement.

Three Message Types

There are three basic message types defined by IEEE 488.2:

- common commands,
- root level commands, and
- subsystem commands.

Common Commands

The IEEE 488.2 Standard designates a set of commands that all instruments must have to guarantee that all instruments have a minimum set of capabilities. All of these commands are prefaced with an asterisk. The syntax of the common command is:

***<message><separator><data><terminator>**

Examples of Common Commands:

`*RST`	Resets oscilloscope to default configuration
`*CLS`	Clears status registers
`*OPC?`	A query that requests status of operation complete register.
`*ESE 1`	Sets event status enable register to 1.

Root Level Commands

The root level commands control many of the basic operations of the oscilloscope. The syntax of the root level command is:

```
:<message><separator><data><terminator>
```

Examples of Root Level Commands:

```
":AUTOSCALE"
```

Performs autoscale.

```
":DIGITIZE CHAN1"
```

Digitizes channel 1.

Subsystem Commands

Configuring the oscilloscope from the front panel usually means finding and setting the function in the appropriate menu. Analogous to the front panel menus are the corresponding HP-IB subsystems. Similar functions are grouped together under a subsystem. For example, the time base range, delay, and reference are all grouped together under the TIMEBASE subsystem.

The syntax of the subsystem command is:

```
:<subsystem>:<function><separator><data><terminator>
```

Examples of Subsystem Commands:

```
":CHAN1:RANGE 20MV"
```

Sets channel 1 sensitivity to 20 mv (2 mv/div).

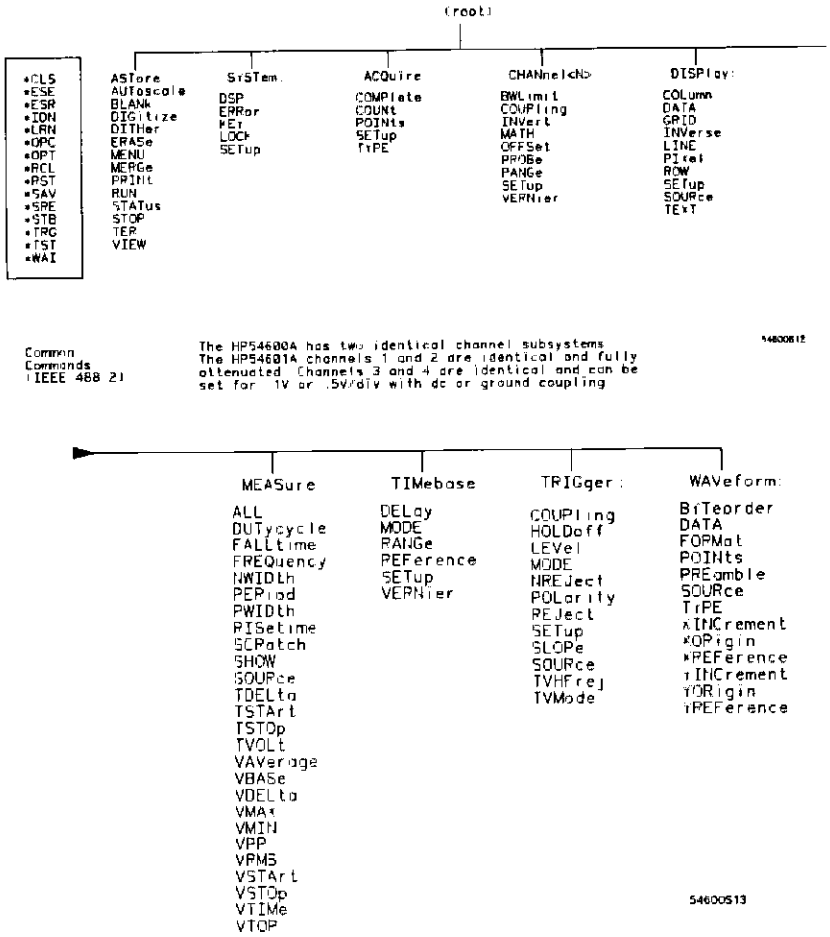
```
":TIMEBASE:RANGE 200US "
```

Sets timebase range to 200 us (20 us/div).

In the first example, the CHANNEL subsystem is specified with the vertical sensitivity being set. In the second example, the TIMEBASE subsystem is specified with the horizontal sensitivity being set. The RANGE function is common to both subsystems, but the oscilloscope will change the appropriate value based on the subsystem specified.

Command Tree and Tree Traversal Rules

The parser is the software inside the oscilloscope that analyzes each command. Understanding the use of the colon, subsystem headers, and terminators by the parser will make programming easier and more efficient. The organization of the oscilloscope commands is best explained through the command tree shown below.



The common commands are commands which are independent of the tree and do not affect the position of the parser within the tree. Root level commands are commands that reside at the root of the command tree. They are prefaced by a colon that puts the parser at the root level. Finally, the subsystem commands are commands that are grouped together under a common node of the tree, such as the TIMEBASE commands.

The following rules apply to traversing the command tree:

- a leading colon places the parser at the root of the tree.
- a program message terminator places the parser at the root of the tree.
- a subsystem command places the instrument in that subsystem until a leading colon or a terminator is found.

Format of Statements

For ease of explaining the sample programs, each statement sent to the oscilloscope will be a single command, written in long form. It is recommended that the short form of the command be used and that the commands be concatenated to improve throughput.

For example, instead of sending:

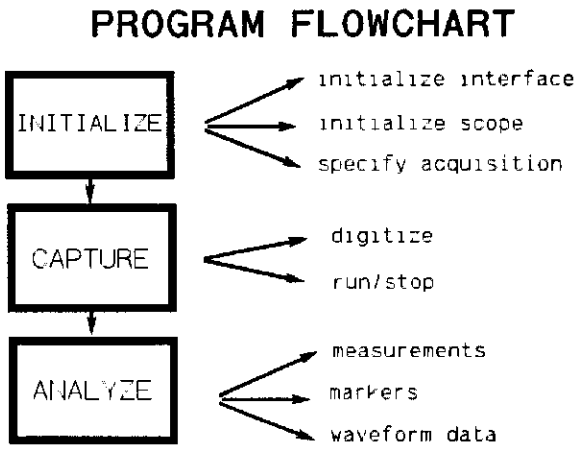
```
":TIMEBASE:RANGE 200MS"
":TIMEBASE:DELAY 100MS",
```

send:

```
":TIM:RANG 200MS;DEL 100MS".
```

Note that the leading colon places the parser at the root level. The command `TIM` enters the timebase subsystem and two timebase commands can be sent. When an end-of-line terminator or another colon is encountered, the parser is reset to the root level.

Fundamental Parts of a Program



Initialize

First, initialize the HP-IB interface and oscilloscope. This step ensures consistent, repeatable performance of the program. Without these initialization procedures, a program may run one time, but not function properly the next time. This may be due to some setting change made either from the front panel or HP-IB which drastically change the configuration of the oscilloscope.

Second, configure the oscilloscope The timebase, channel, and trigger systems are set for the desired measurement.

Finally, specify the ACQUIRE subsystem. From the front panel, the only setting that can be made is the mode (such as normal, average, or envelope). But over the bus, you can set the number of points to be acquired and the completion criteria -- both impact throughput.

Capture

Even though the oscilloscope has been properly initialized and set up, measurements cannot yet be made. It must be noted that when the oscilloscope is responding to HP-IB commands, it is in an interrupt mode, and the data acquisition process is being held off. Changes to the oscilloscope's configuration invalidate previously collected data As a result, if a measurement is requested immediately, there may not be sufficient waveform data available to analyze. Therefore, it is recommended that the next program step is to capture the data using the DIGITIZE command.

The DIGITIZE command captures data as specified by you. It is a macro that first clears the waveform data buffers and then starts the acquisition process. Acquisition continues until the criteria, such as number of averages, completion criteria, and number of points, is satisfied. Once the criteria is satisfied, the acquisition process stops. The signal is displayed on the oscilloscope, and the captured data can be measured, stored in memory, or transferred to the computer for analysis Additional commands are stored in a buffer of the oscilloscope until the DIGITIZE is completed.

An alternative to the DIGITIZE command is to let the oscilloscope run with a wait in the program before doing any measurements. This method is not recommended because the length of the wait is an indeterminant value. The DIGITIZE command gives confidence to the measurement by ensuring complete data capture. In addition, the DIGITIZE stops the acquisition process, so all measurements are made on the data being displayed, not on a continually changing set of data.

Analyze

Once the data has been captured, measurements can be made. The measurements can include the IEEE standard parametric measurements (such as Vpp, Frequency, + width) or the positioning and reading of voltage and time markers. The waveform data can be transferred from the oscilloscope into the computer for special analysis, if desired.

Getting Started

Before any communication can occur between the computer and oscilloscope, the oscilloscope must be properly configured to talk with the computer over the bus. This MUST be done from the front panel because the HP 54600A series of oscilloscopes are configured to talk to a printer and not to a computer.

To configure the HP 54600A series oscilloscope:

1 From the front panel, select the Print/Utility menu.

2 Select the HP-IB menu.

3 Set the mode to connect to "computer". Set the address as desired (7 is used in this guide).

Note: default setting is connect to "HP Print" and address 1.

4 Connect a signal to the oscilloscope:

This sample program assumes that a signal is available on channel 1. You should use the 10:1 probe that was shipped with the oscilloscope and connect the AC signal on the front panel to channel 1 input.

Links to HP-IB Drivers

To run programs in either QuickC or QuickBASIC, you must link to various libraries and include files. The HP-IB Command Library disks contain an INSTALL program that copies the C Library files or the BASIC Library files to your system for you. The location of these files will depend on your computer configuration and where you specify the files to be installed. Refer to your HP-IB Interface manual for details.

Also make sure QuickC or QuickBASIC is installed properly. Refer to your Microsoft programming manual for details.

Microsoft QuickBASIC Library

If writing in Microsoft QuickBASIC, you must link to the HP-IB library file qbhpib qlb, with the path for your system.
For example:

```
qb /l c:\hpib\qbhpib.qlb
```

Microsoft QuickC Libraries

If writing in Microsoft QuickC, you must link to the HP-IB library file clhpib.lib, with the path for your system. To do this, you must first enter the Options menu and turn full menus on. Leave the Options menu and enter the Make menu. Choose Set Program List and link your source program to the HP-IB library.
For example, with the path for your system, link to:

```
c:\qc25\lib\clhpib.lib
```

For complete instructions on this linking process, see the Microsoft "Up and Running" Manual ("Compiling and Linking" section).

In the sample QuickC program, the graph function draws the oscilloscope's signal on the PC display. If you use this function, you must include GRAPHICS.LIB in the combined libraries while installing QuickC. If you did not include it, link explicitly to the graphics library GRAPHICS.LIB in the Make menu of the QuickC environment.

Another Microsoft QuickC setting that may need to be reviewed is the size of the stack. The stack size is set to a default value of 2048. If your program has a function that has a large local array, this default stack setting does not provide sufficient space, resulting in a stack overflow problem. To reset the size of the stack, first select the Options menu. Next enter the Make dialog box and there select the "Linker Flags". Set the stack size to handle your local variables. For example, in the sample program, the integrate function declares a real array of 4000 for the integral values, hence the stack size was set at 36,000.

Sample Program Structure

The sample program in this guide is written in both QuickC and QuickBASIC. The sample program follows the format of initialize, capture and analyze as discussed in the "Three Fundamental Parts of a Program" section. The programs are written in modular form to allow detailed discussion of each function. You can write a custom program by selecting and modifying these modules. Also, refer to the disk supplied with the *HP 54600A Programmer's Guide*. The programs on the disk are very similar to the sample program in this guide.

The sample program first initializes the oscilloscope and HP-IB interface and then acquires a signal. The program then performs some parametric measurements, transfers the waveform data from the oscilloscope to the PC, and saves the waveform data to the PC disk. The program then retrieves the waveform data from the PC disk, draws the signal on the PC display, calculates the integral of the signal, and draws the integral on the PC display.

Both the QuickC and QuickBASIC sample programs contain the following fundamental modules:

main program:	Define global variables and constants; specify include files; call the various functions.
initialize:	Initialize HP-IB and oscilloscope; setup oscilloscope and acquire subsystem
capture_waveform:	Digitize waveform to capture data.
measure:	Perform simple parametric measurement
get waveform:	Bring waveform data and voltage/timing information (preamble) into computer.
save_waveform:	Store the waveform data and preamble information to a PC disk file.
retrieve_waveform:	Retrieve waveform data and preamble information from a PC disk file.
graph:	Plot the waveform on computer display with scaling information derived from preamble.
integrate:	Convert waveform data to volts, summing to calculate and plot the integral of the signal.

Programming with QuickC

```
#include "c:\qc25\chpib.h"      /*HPIB library consant declarations  */
#include "c:\qc25\cfunc.h"      /*HPIB library function              */
#include  <stdio.h>             /*used for printf()                  */
#include <graph.h>              /*used for pc graphics routines      */
float     preamble[10];         /*real array to hold volt/time info  */
unsigned char waveform[4000];   /*array to hold waveform data        */
#define  ISC    7L              /*HPIB card address; must be long    */
#define SCOPE ISC*100 + 7L      /*oscilloscope address; must be long */
#define  TRUE   1               /*constant used in graph function    */

main()
{
  initialize();          /*initialize interface,scope & acquisition */
  capture_waveform();    /*digitize signal                          */
  measure();             /*do Vpp and frequency measurement         */
  get_waveform();        /*bring waveform & preamble into computer  */
  save_waveform();       /*store waveform & preamble to disk file   */
  retrieve_waveform();   /*retrieve waveform & preamble from disk   */
  graph();               /*plot waveform data & scaling info on PC  */
  integrate();           /*calculate and plot integral of signal    */
 }
```

Four include statements start the program. The files, chpib.h and cfunc.h, define needed constants, an error string procedure, and function prototyping. The file cfunc.h is not mandatory for a large memory model program, its inclusion helps reveal variable-type problems. The path of these files must specify the disk drive and directory where these .h files reside. The stdio.h file is needed whenever input or output functions are used. The graph.h file is needed whenever graphics functions are used

Two global arrays are defined for the waveform data and preamble information. These arrays are needed ONLY if the waveform data is to be read into the computer for further analysis or storage.

The preamble array must be a real array of size 10. The preamble information is used to convert the raw waveform data into voltage and time pairs.

The size and structure of the waveform data array may vary with the language, oscilloscope, and format of the data. For QuickC, an unsigned char array is used with the HP 54600A with a waveform format of byte. The waveform data formats and preamble information are covered in detail in the "Waveform Data and Preamble" section of this guide.

The Interface Select Code (ISC) is defined as 7L It must be a long as it is used as a parameter in the HP-IB library calls. The ISC address is set by a dip switch on the HP-IB card.

The oscilloscope address, SCOPE, is defined as ISC*100 + 7L. The "7" is the address of the oscilloscope as set on the front panel in the HP-IB menu. This value must also be a long as it is used as a parameter in the HP-IB library calls.

The value of TRUE is defined as 1 and is used in the graph function.

Handling Errors

```
error_handler (error,routine)
int error;                  /*error number                          */
char *routine;              /*name of routine generating error      */
 {
 char ch;
 if (error != NOERR)
   {
     printf("Error in call to %s \n",routine);
     printf("%d %s \n",error,errstr(error));

     printf("press Enter to continue: ");
     printf("%c",ch = getchar());
   }
}                           /*end error_handler                     */
```

Errors may occur while communicating over the bus. To avoid hanging up the interface and computer, it is recommended that an error handling funtion be used.

In the function header, an error variable is declared to hold the error number. A string is also declared to hold the name of the command (or other descriptor) in which the error occurred.

If an error occurs, a message is printed telling you where the error occurred. The error number and error message string are printed. The errstr routine returns the error message string and is explained in the "C Error Handling" section of the HP-IB manual. To let you see the error message, the function pauses until the "Enter" key is pressed on the PC keyboard. Note that Ctrl-C will terminate the program.

Sending a Message Using String Output:

```
send (cmd)
char *cmd;          /*ASCII string to be sent to oscilloscope      */
{
   error_handler (IOOUTPUTS(SCOPE, cmd, strlen(cmd)),cmd);
}
```

To simplify the format of the sample program when sending messages to the oscilloscope, a generic output function has been written. The use of the "send" function simply makes the code easier to read. Instead of a call to the IOOUTPUTS function and the associated error checking, a single call is made to the function "send". The function then sends the ASCII string to the oscilloscope and the error handler routine prints any errors.

This generic string output function uses the HP-IB IOOUTPUTS function to output an ASCII string to the oscilloscope. The three parameters of IOOUTPUTS are the address of the instrument, the string to be sent, and the length of the string. If an error is encountered, the error handling routine prints the error.

Initializing the HP-IB and the Oscilloscope

```
initialize ()
{
  error_handler(IORESET(ISC),"IORESET");          /*reset interface    */
  error_handler(IOTIMEOUT(ISC,(double)10),"IOTIMEOUT");
                                                  /*set bus timeout    */
 error_handler(IOCLEAR(ISC),"IOCLEAR");           /*clear interface    */

 send ("*rst");  /*restore oscilloscope to default configuration     */
 send (":autoscale");                 /*autoscale   oscilloscope     */
 send (":channel1:probe x10");                    /**probe setting     */

 /*set up acquisition subsystem: some are set by *rst, but are       */
 /*                          included for completeness               */
 send (":acquire:type normal");                   /*normal acq mode    */
 send (":waveform:points 4000");                  /*4000 data points   */

 send (":acquire:complete 100");                  /*100% completion    */

 _clearscreen(_GCLEARSCREEN);                     /*clear PC's screen */

}
```

Initializing the HP-IB Interface

IORESET sets the HP-IB interface to its start-up state (see the HP-IB manual for complete description).

IOTIMEOUT sets an interface timeout value in seconds to handle I/O operations that do not complete (for example, the HP-IB cable is not attached or the oscilloscope address is not correct).

IOCLEAR clears the interface in computer and all attached devices.

Initializing the Oscilloscope

The *RST is a common command that resets the oscilloscope to a known default configuration. Using this command will ensure that the oscilloscope is in a known state before configuring the oscilloscope. Using the *RST command will ensure very consistent, repeatable results. Without the *RST, a program may run one time, but the program may give different results the next time if the socpe is differently configured. For example, if the trigger mode is normally set to the edge trigger mode, the program may function properly. But if someone put the oscilloscope into the tv trigger mode from the front panel, the program may result in signals and measurements that are totally incorrect. The *RST defaults to a set configuration, so the program may proceed from a given state each time.

The autoscale function will find and display all signals attached to the oscilloscope You may or may not wish to have this done. It is probably advisable to program the oscilloscope's time base, channel, and trigger for the specific measurement to be made (just as would be done from the front panel). For example:

```
:chan1:range 8
```

sets vertical sensitivity to 1 V/div

```
:timebase:range 2
```

sets horizontal sensitivity to 200 ms/div

and use the other commands as needed to configure oscilloscope for desired measurement.

Specifying the Acquisition

From the front panel, the acquisition mode is set using the display menu and selecting the desired display mode such as normal or average. For the normal front panel run mode, this is the only control that needs to be made. For the average mode, the number of averages needs to be set.

When programming the oscilloscope over the bus and using the DIGITIZE command to ensure data capture, the ACQUIRE subsystem needs to be initialized. The most common ACQUIRE subsystem command is TYPE, where the aquisition mode of normal or average is set. If selecting the average mode, COUNT will control the number of averages to be taken.

In addition, for the DIGITIZE, you may indicate the number of data points to be acquired. The number of data points specified will depend upon time base setting and the acquisition type. In general, the fewer number of points acquired, the faster the acquisition will complete, but with a loss in timing resolution.

You may also specify a COMPLETE criteria between 0 and 100 percent. The DIGITIZE command will force the acquisition to run until the complete criteria is satisfied. All other commands to the oscilloscope are held off until the DIGITIZE is complete. Depending on the time base range and acquisition mode, setting the completion criteria to a value lower than 100% may significantly improve throughput while still providing sufficient data for very accurate measurements.

Capturing Data

```
capture_waveform()
{
 send (":digitize channel1");      /*capture data for channel 1     */
}
```

At this point, the oscilloscope and interface are completely configured. It is now suggested that the DIGITIZE operation be performed. DIGITIZE is a macro that clears the data buffers and acquires data for the requested channels to the specifications that you have set. When the data has been acquired, the acquisition process is stopped and the signal is displayed on the oscilloscope display. The data may then be measured using the parametric measurements or markers, or it may be stored in memory, or it may be transferred over the bus without the data changing.

The use of the DIGITIZE is highly recommended as it will ensure that sufficient data is available for measurement. Keep in mind that when the oscilloscope is running, communication with the computer interrupts data acquisition. Setting up the oscilloscope over the bus causes the data buffers to be cleared and the internal oscilloscope hardware to be reconfigured. If a measurement is immediately requested, there may not have been enough time for the data acquisition process to collect data and the results may be questionable When operating from the front panel, the measurement may momentarily reflect "not found", but is quickly updated, but over the bus only the error value of 9.9E+37 is returned if there is insufficient data.

In the HP 54600A, all channels that are currently on when the digitize command is sent are acquired. However, only those channels that are part of the command are acquired to the specified completion and acquire criteria. For this reason, it is suggested that the VIEW command be used to turn on channels that are to be acquired and the BLANK command be used to turn off undesired channels. This will improve the throughput of the DIGITIZE command.

Making Measurements

```
measure()
{
   float vpp_value, frequency;
   char ch;

 send (":measure:vpp?");          /*query oscilloscope for Vpp      */
 error_handler(IOENTER(SCOPE,&vpp_value)); /*input Vpp             */
 send (":measure:frequency?");    /*query oscilloscope for freq     */
 error_handler(IOENTER(SCOPE,&frequency));/*inputfrequency          */
 printf ("Vpp = %f V \n",vpp_value);      /*print Vpp               */
 printf ("freq = %f Hz \n",frequency);    /*print frequency         */
 printf ("Press Enter to continue:");     /*pause for display       */
 ch = getch();                            /*read keypad to continue*/
}
```

After a digitize command, the signal is displayed on the screen and the acquisition process is stopped. Any of the parametric measurements can be made on this data using either the parametric measurements (such as Vpp, frequency, pwidth) or markers (such as VTIME, TVOLT, ESTART). All measurements use the IEEE standard for making measurements.

Measurement Query

When a measurement query is sent to the oscilloscope, the specified measurement is made and the result is stored in the output buffer of the oscilloscope. The next operation in the program is to read that measurement result into the computer. If another command or query is sent to the oscilloscope before the results are read, the error "QUERY INTERRUPTED" is displayed on the oscilloscope display.

Error in Measurements (9.9E+37)

If the DIGITIZE command was not used to acquired data after configuring the oscilloscope, or if the oscilloscope was not given sufficient time to acquire data, there may not be enough waveform data available to make a valid measurement. In this case, the error value of 9 9E+37 is returned.

If the signal cannot be analyzed, the error value will also be returned. For example, if the signal is clipped, a Vpp measurement cannot be made. Or, if a whole period of the signal is not display, a frequency measurement cannot be made. In both cases, the error value of 9.9E+37 will be returned.

Transferring Waveform Data to the PC

```
get_waveform()
{
 int length;                          /*size of data transfers        */
 char msg[5];                         /*scratch buffer                */
 send (":waveform:format byte");      /*54600 8 bit data format       */
 send (":waveform:preamble?");        /*query for volt/time info      */
 length = 10;
 error_handler(IOENTERA(SCOPE,preamble,&length),"preamble");
 send (":waveform:data?");            /*query for waveform data       */
 length = 4000;                       /*max size to be read           */
 error_handler(IOENTERAB(SCOPE,waveform,&length,1),"waveform");
 length = 1;                         /*input line feed character      */

 error_handler(IOENTERS(SCOPE,msg,&length),"read line feed");
}
```

After the DIGITIZE operation, the acquisition process is stopped. The data that is displayed on the oscilloscope can be transferred to the computer, if desired, for storage to a file, for plotting to the computer display, or for further analysis.

The preamble information is an array of 10 real numbers that contains voltage and time scaling information that is used to convert the waveform data from a oscilloscope format to voltage and time. To transfer the preamble information, the formatted array transfer command, IOENTERA, is used.

The waveform data is a block of data consisting of a header (specifying the number of bytes of data that are to be transferred), the data in the selected format, and a terminating character (line feed). The arbitrary block data command, IOENTERAB, is used to transfer the data from the oscilloscope to the computer. All the data, except for the terminator, is read from the oscilloscope with the arbitrary block data command. The terminator is read using a string command, IOENTERS

Before doing the arbitrary block data command, the value of length is set to 4000. This specifies the maximum number of bytes to be read. This value is determined by the number of points specified in the initialize function and the format requested.

In this example, the data is transferred out in the 8-bit format as QuickC has an unsigned char data structure The data from the oscilloscope will be between 0 and 255

NOTE: Both preamble and waveform data block are described in detail in the "Waveform Data and Preamble" section.

Storing Waveform Data and Information to the PC Disk

```
save_waveform()
{
  FILE *fp;
  fp = fopen("wave.dat", "wb");
  fwrite (preamble, sizeof(preamble[0]), 10, fp);
  fwrite (waveform, sizeof(waveform[0]), (int)preamble[2], fp);
  fclose (fp);
}
```

Once the waveform data and preamble information are in the computer, you may want to store this data to the disk for future reference.

In the program, a disk file is opened, the preamble array and waveform data are written to the file, and the file is closed.

Please note that for QuickC, the size of the waveform data record is the value in preamble[2] since C arrays start at zero, and the number of data points collected is in the third element of the preamble array.

Retrieving Waveform Data and Information from the PC Disk

```
retrieve_waveform()
{
  FILE *fp;
  fp = fopen("wave.dat", "rb");
  fread (preamble, sizeof(preamble[0]), 10, fp);
  fread (waveform, sizeof(waveform[0]), (int)preamble[2], fp);
  fclose (fp);
}
```

The preamble information and waveform information have been stored to a disk for retrieval when desired. To illustrate the retrieval process, the data will be read from disk by this function even though both the waveform data and preamble information arrays have valid data in them.

Drawing the Signal on the PC Display

```
graph()
{
   int    i;
   float  max, min;


 _setvideomode ( _ERESCOLOR);          /*set up EGA graphics          */
 _rectangle (_GBORDER, 0, 0, 639, 257);      /*draw border           */
 _setviewport (1, 1, 638, 256);        /*set viewport                 */
 _setwindow (TRUE, 0, 0, 10, 8);       /*set mapping coordinates      */
 _setcolor(8);                         /*set color                    */
  for (i = 1; i < 10; i++)              /*plot graticule              */
  {
    _moveto_w(i,0);
    _lineto_w(i,8);
   }
  for (i = 1; i < 8; i++)
   {
    _moveto_w(0,i);
    _lineto_w(10,i);
   }
 _setwindow(TRUE,1,0,preamble[2],255);/*set mapping coordinates     */
  _setcolor(10);
  for (i = 0; i < preamble[2]; i++)   /*plot waveform data           */
    _setpixel_w (i, waveform[i]);

 _settextwindow(20, 1, 24, 80);        /*set text window             */
 _settextposition (1, 1);             /*position cursor              */
 _settextcolor (15);                 /*set color: bright white       */
 printf ("V/div = %f V \n", 32 *preamble[7]);
  _settextposition (1,41);
 printf ("Offset=%V\n",(128-preamble[9])*preamble[7]+preamble[8]);
  _settextposition (2,1);
 printf ("S/div = %f S \n",preamble[2]*preamble[4]/10);
}
```

With graphics, you can add a visual dimension to the program, and often you will want to see the waveform displayed on the PC. To run graphics, your computer must have graphics capability, either built in or in the form of a graphics card such as the Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), or Video Graphics Array (VGA). You also need a video display (monochrome or color) that supports pixel-based graphics.

This sample program was written for an EGA adapter. When using the program, the _setvideomode, rectangle, setviewport, and setcolor commands may need to be altered to conform to your configuration.

The graphics library GRAPHICS.LIB contains functions for drawing lines, rectangles, and other shapes. The library can either be included in the combined libraries when installed, or can be explicitly linked in the MAKE menu.

Although the oscilloscope can be queried for its current settings of V/div, offset, and s/div, the preamble information will be used to calculate these settings. These scaling factors are displayed under the graticule. The calculations are explained in "Waveform Data and Preamble" section of this guide.

Calculating and Drawing the Integral of the Signal

```
integrate()
{
   float math[4001],min,max;  /*define array to hold math data      */
   int   i;
   math[0] = 0;                    /*start from zero                 */
   for (i = 0;i < preamble[2];i++)/*calculate integral of signal    */
     math[i+1] = math[i] + (waveform[i]-preamble[9])*preamble[7]+
                 preamble[8];
   max = math[1];                  /*find max and min of integral    */
   min = math[1];                 /*to set up graphics scaling       */
   for (i = 1; i <= preamble[2]; i++)
    {
     if (math[i] > max) max = math[i];
     if (math[i] < min) min = math[i];
    }
  _setwindow(TRUE,1, min, preamble[2],max);/*set up mapping         */
  _setcolor(12);

   for (i = 1; i <= preamble[2]; i++)
     _setpixel_w(i, math[i]);              /*plot integral          */
}
```

Another interesting exercise is to use the waveform data and the preamble information to calculate and plot the integral of the signal. The voltage of each data point is calculated using the preamble and this voltage value is summed to compute the integral.

These calculations are described in "Waveform Data and Preamble", the last section of this guide.

Programming withQuickBASIC

```
REM $INCLUDE: 'c:\hpib\qbsetup''QuickBasic header

DIM SHARED waveform%(4000)      'integer waveform data array
DIM SHARED preamble!(10)        'real array for volt/time info
DIM SHARED scope&,isc&          'long variable for addresses
isc&= 7                         'HP-IB Interface Select Code
scope& =isc&*100 +7             'scope address

CALL initialize          'initialize interface and oscilloscope
CALL capture.waveform    'digitize signal
CALL measure             'do VPPand Frequency measure
CALL get.waveform        'bring waveform & preamble into computer
CALL save.waveform       'store waveform & preamble to disk
CALL retrieve.waveform   'retrieve waveform & preamble from disk
CALL graph               'plot waveform data & scaling info
CALL integrate           'calculate and plot integral of signal
END
```

The header for the program is qbsetup . It sets up the necessary error status variables, declares some working variables, contains related COMMON statements and establishes an error handling routine.

Two global arrays (waveform and preamble) are defined for the waveform data and preamble information. These arrays are need ONLY if the waveform data is to be read into the computer for further analysis or storage.

The preamble array must be a real array of size 10. The preamble information is used to convert the raw waveform data into voltage and time pairs. The size and structure of the waveform data array may vary with the language, oscilloscope, and format of the data.

For QuickBASIC, an integer array is used for the HP 54600A with a waveform format of word. The waveform data formats and preamble information are covered in detail in the "Waveform Data and Preamble" section of this guide.

The Interface Select Code, isc&, is set equal to 7. This must be a long variable as it is used as a parameter in the HP-IB library calls. The ISC address is set by a dip switch on the HP-IB card.

The oscilloscope address, scope&, is set equal to isc&*100+7. The "7" is the address of the oscilloscope as set on the front panel in the HP-IB menu. This must be a long variable as it is used as a parameter in the HP-IB library calls.

Handling Errors

Errors may occur while communicating over the bus. To avoid hanging up the interface and computer, it is recommended that an error handling procedure be used to report the errors.

An error handling routine is included with QBSETUP BAS. If a subroutine detects an error, the error number is placed into the variable PCIB.ERR. A text error message is placed into the variable PCIB.ERR$.

After each subroutine call, if the value of the variable PCIB.ERR is 0, no error conditions have been detected. However, if its value is not 0, then the error message will be printed by transferring control, via BASIC's error trapping facilities, to an error handling routine in the QBSETUP.BAS file.

It is important to know that the variables PCIB.ERR, PCIB.BASERR, and NOERR are specified as COMMON in QBSETUP.BAS. This means that in the main program or any functions, these variables are recognized. However, if using subprograms (as in the sample program), they will not be part of the subprogram environment and must be specified as SHARED variables in any subprograms where they are used.

Sending a Message Using String Output

```
SUB send(cmd$)
SHARED PCIB.ERR, PCIB.BASERR, NOERR

 CALL iooutputs(scope&, cmd$, LEN(cmd$))
 IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
END SUB
```

To simplify the format of the sample program when sending messages to the oscilloscope, a generic output function has been written. The use of the "send" function simply makes the code easier to read. Instead of a call to the IOOUTPUTS function and the associated error checking, a single call is made to the function "send". The function then sends the ASCII string to the oscilloscope and calls the error handler routine if needed.

This generic string output function uses the HP-IB IOOUTPUTS function to output an ASCII string to the oscilloscope. The three parameters of IOOUTPUTS are the address of the instrument, the string to be sent, and the length of the string. If an error is encountered, the error handling routine will be invoked.

Initializing the HP-IB Interface and the Oscilloscope

```
SUB initialize
SHARED PCIB.ERR, PCIB.BASERR, NOERR
 CALL ioreset(isc&)              'reset HP-IB interface
 if PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR   'error handler
 timeout.val!=10
 CALL iotimeout (isc&,timeout.val!) 'set timeout to 10 seconds
 IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
 CALL ioclear(isc&)              'clear interface and oscilloscope
 IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
 send ("*rst")              'reset oscilloscope to default config
 send (":autoscale")             'autoscale oscilloscope
 send (":channel1:probe x10")  'probe setting
 'set up acquisition subsystem:  some are set by *rst, but are
 '                              included for completeness
 send (":acquire:type normal") 'normal acq mode
 send (":waveform:points 4000") '4000 data points
 send (":acquire:complete 100")  '100% completion
 CLS                            'clear screen of PC
END SUB
```

Initializing the HP-IB Interface

IORESET sets the HP-IB interface to its start-up state (see the HP-IB manual for complete description).

IOTIMEOUT sets an interface timeout value in seconds to handle I/O operations that do not complete (for example, the HP-IB cable is not attached or the oscilloscope address is not correct).

IOCLEAR clears the interface in the computer and all attached devices.

Initializing the Oscilloscope

The *RST is a common command that resets the oscilloscope to a known default configuration. Using this command will ensure that the oscilloscope is in a known state before configuring the oscilloscope. Using the *RST command will ensure very consistent, repeatable results. Without the *RST, a program may run one time, but the program may give different results the next time if the scope is differently configured. For example, if the trigger mode is normally set to the edge trigger mode, the program may function properly. But if someone put the oscilloscope into the tv trigger mode from the front panel, the program may result in signals and measurements that are totally incorrect. The *RST defaults to a set configuration, so the program may proceed from a given state each time.

The autoscale function will find and display all signals attached to the oscilloscope. You may or may not wish to have this done. It is probably advisable to program the oscilloscope's time base, channel, and trigger for the specific measurement to be made (just as would be done from the front panel) For example:

```
:chan1:range 8
```

sets vertical sensitivity to 1 V/div

```
:timebase:range 2
```

sets horizontal sensitivity to 200 ms/div

and use other commands as needed to configure oscilloscope for desired measurement.

Specifying the Acquisition:

From the front panel, the acquisition mode is set using the display menu and selecting the desired display mode such as normal or average. For the normal front panel run mode, this is the only control that needs to be made. For the average mode, the number of averages needs to be set.

When programming the oscilloscope over the bus and using the DIGITIZE command to ensure data capture, the ACQUIRE subsystem needs to be initialized. The most common ACQUIRE subsystem command is TYPE, where the aquisition mode of normal or average is set. If selecting the average mode, COUNT will control the number of averages to be taken.

In addition, for the DIGITIZE, you may indicate the number of data points to be acquired. The number of data points specified will depend upon time base setting and the acquisition type. In general, the fewer number of points acquired, the faster the acquisition will complete, but with a loss in timing resolution.

You may also specify a COMPLETE criteria between 0 and 100 percent. The DIGITIZE command will force the acquisition to run until the complete criteria is satisfied. All other commands to the oscilloscope are held off until the DIGITIZE is complete. Depending on the time base range and acquisition mode, setting the completion criteria to a value lower than 100% may significantly improve throughput while still providing sufficient data for very accurate measurements.

Capturing Data

```
SUB capture.waveform
 send (":digitize channel1)    'capture data for channel 1
END SUB
```

At this point, the oscilloscope and interface are completely configured. It is now suggested that the DIGITIZE operation be performed. DIGITIZE is a macro that clears the data buffers, acquires data for the requested channels to the specifications that you have set, and finally, stops the acquisition process when complete, displaying the signal on the oscilloscope display. The data may then be measured using the parametric measurements or markers, or it may be stored in memory, or it may be transferred over the bus without the data changing.

The use of the DIGITIZE is highly recommended as it will ensure that sufficient data is available for measurement. Keep in mind that when the oscilloscope is running, communication with the computer interrupts data acquisition. Setting up the oscilloscope over the bus causes the data buffers to be cleared and the internal oscilloscope hardware to be reconfigured. If a measurement is immediately requested, there may not have been enough time for the data acquisition process to collect data and the results may be questionable. When operating from the front panel, the measurement may momentarily reflect "not found", but is quickly updated, but over the bus only the error value of 9.9E+37 is returned.

In the HP 54600A, all channels that are currently on when the digitize command is sent are acquired. However, only those channels that are part of the command are acquired to the specified completion and acquire criteria. For this reason, it is advised that the VIEW command be used to turn on channels that are to be acquired and the BLANK command be used to turn off undesired channels. This will improve the throughput of the DIGITIZE command.

Making Measurements

```
SUB measure
 SHARED PCIB.ERR, PCIB.BASERR, NOERR

   send (":measure:vpp?")                    'query oscilloscope for Vpp
   CALL IOENTER (scope&,vpp_value!)'input Vp
   IF  PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
   PRINT "Vpp = ";vpp_value!                 'print Vpp
   send (":measure:freq?")                    'queryscope for frequency
   CALL IOENTER (scope&, freq!)              'input frequency
   IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
   PRINT "frequency = ";frequency;" Hz"      'print frequency
   INPUT "Press Enter to continue",a$        'read keypad
END SUB
```

After a digitize command, the signal is displayed on the screen and the acquisition process is stopped. Any of the parametric measurements can be made on this data using either the parametric measurements (such as Vpp, frequency, pwidth) or markers (such as VTIME,TVOLT, ESTART). All measurements use the IEEE standard for making measurements.

Measurement Query

When a measurement query is made to the oscilloscope, the specified measurement is made and the result is stored in the output buffer of the oscilloscope. The next operation in the program is to read that measurement result into the computer. If another command or query is sent to the oscilloscope before the results are read, the error "QUERY INTERRUPTED" will be displayed on the oscilloscope display.

Error in Measurements (9.9E+37)

If the DIGITIZE command was not used to acquired data after configuring the oscilloscope, or if the oscilloscope was not given sufficient time to acquire data, there may not be enough waveform data available to make a valid measurement. In this case, the error value of 9.9E+37 will be returned.

If the signal cannot be analyzed, the error value is also returned. For example, if the signal is clipped, a Vpp measurement cannot be made. Or, if a whole period of the signal is not display, a frequency measurement cannot be made. In both cases, the error value of 9.9E+37 is returned.

Transferring Waveform Data to the PC

```
SUB get.waveform
SHARED PCIB.ERR,NOERR,PCIB.BASERR
   send (":waveform:format word")          '16-bit format
   send (":waveform:preamble?)             'query for volt/time info
   max.len% = 10
   actual.len% = 0
   CALL ioentera (scope&, SEG preamble!(1),max.len%,actual.len%)
   IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR

   send (":waveform:data?")                'query for waveform data
   max.len% = 8000                         'max size of record
   actual.len%=0
   CALL ioenterab(scope&,SEG waveform%(1),max.len%,actual.len%,2)
   IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
   max.len% = 1                            'get line feed at end
   actual.len%=0
   msg$ = SPACE$(max.len%)
   CALL ioenters (oscilloscope&, msg$, max.len%,actual.len%)
   IF PCIB.ERR<>NOERR THEN ERROR PCIB.BASERR
END SUB
```

After the DIGITIZE operation, the acquisition process is stopped. The data that is displayed on the oscilloscope can be transferred to the computer, if desired, for storage to a file, for plotting to the computer display, or for further analysis.

The preamble information is an array of 10 real numbers that contains voltage and time scaling information that is used to convert the waveform data from a oscilloscope format to voltage and time. To transfer the preamble information, the formatted array transfer command, ioentera, is used.

The waveform data is a block of data consisting of a header (specifying the number of bytes of data that are to be transferred), the data in the selected format, and a terminating character (line feed). The arbitrary block data command, ioenterab, is used to transfer the data from the oscilloscope to the computer. All the data, except for the terminator, is read from the oscilloscope with the arbitrary block data command. The terminator is read using a string command, ioenters.

The value that the variable max.len% is set to before the arbitrary block command specifies the maximum number of bytes to be read. This value is determined by the number of points specified in the initialize function and the format requested.

In this example, the data is transferred out in the word format. This transfers 16 bits of data into an integer array. The data will be between 0 and 255.

NOTE: Both the preamble and waveform data block are described in detail in the "Waveform Data and Preamble" section of this guide.

Storing Waveform Data and Information to the PC Disk

```
SUB save.waveform
  OPEN "wave.dat" FOR BINARY AS #2
  FOR count% = 1 to 10
       PUT #2, , preamble!(count%)
  NEXT count%
  FOR count% = 1 TO preamble!(3)
       PUT #2, , waveform%(count%)
  NEXT count%
  CLOSE #2
 END SUB
```

Once the waveform data and preamble information are in the computer, you may want to store this data to the disk for future reference.

In the program, a disk file is opened, the preamble array and waveform data are written to the file, and the file is closed.

In the QuickBASIC example, the size of the waveform data record is the value in preamble!(3) since BASIC arrays start at one, and the number of data points collected is in the third element of the preamble array.

Retrieving Waveform Data and Information from the PC Disk

```
SUB retrieve.waveform
  OPEN "wave.dat" FOR BINARY AS #2
  FOR count% = 1 to 10
      GET #2, , preamble!(count%)
  NEXT count%
  FOR count% = 1 to preamble!(3)
      GET #2, , waveform%(count%)
  NEXT count%
  CLOSE #2
END SUB
```

The preamble information and waveform information have been stored to a disk for retrieval at any time. To illustrate the retrieval process, the data will be read from disk by this function even though both the waveform data and preamble information arrays have valid data in them.

Drawing the Signal on the PC Display

```
SUB graph
  SCREEN 9                          'set screen mode to EGA
                                    '640 x 200 x 2
  VIEW (1,1)-(638,256), ,15         'set viewport and draw border
  WINDOW (0,0)-(10,8)               'prepare to draw the grid
  COLOR 8
  FOR i% = 1 TO 9
    LINE (i%,0)-(i%,8)
  NEXT i%
  FOR i% = 1 TO 7
    LINE (0,i%)-(10,i%)
  NEXT i%
  WINDOW (1,0)-(preamble!(3),255)'window on max data of 255
  COLOR 10
  FOR i% = 1 TO preamble!(3)
      PSET (i%, waveform%(i%))
  NEXT i%

  'use preamble information to calculate scaling information
  WDITH 80, 25
  VIEW PRINT 20 TO 24
  LOCATE 20, 1
  PRINT "V/DIV =";  (32*preamble!(8));" V"
  PRINT "Offset = ";(128-preamble!(10))*preamble!(8)
                   +preamble!(9);"V"
  LOCATE 20, 41
  PRINT "S/Div = "; preamble!(3)*preamble!(5)/10;" S"
END SUB
```

With graphics, you can add a visual dimension to the program, and often you will want to see the waveform displayed on the PC. To run graphics, your computer must have graphics capability, either built in or in the form of a graphics card such as the Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), or Video Graphics Array (VGA). You also need a video display (monochrome or color) that supports pixel- based graphics.

Although the oscilloscope can be queried for its current settings of V/div, offset, and s/div, the preamble information is used to calculate these settings. These scaling factors are displayed under the graticule. All of the calculations are described in "Waveform Data and Preamble", the last section of this guide.

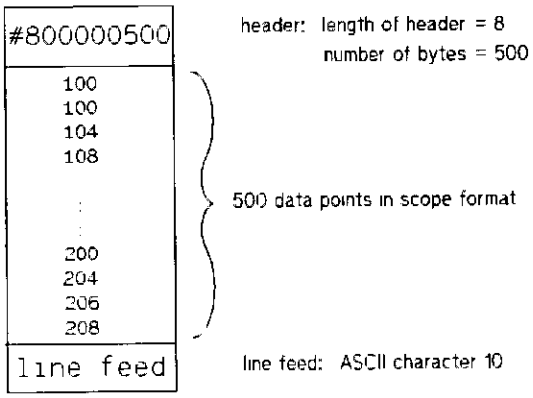
Calculating and Drawing the Integral of the Signal

```
SUB integrate
  SHARED PCIB.ERR, PCIB.BASERR, NOERR
  DIM math!(preamble!(3))       'define array for math data
  math!(0) = 0                  'start from zero
  FOR i% = 1 TO preamble!(3)    'calc and sum integral
  math!(i%) = math!(i%-1) + (waveform%(i%)-preamble!(10))
                *preamble!(8) + preamble!(9)
   NEXT i%
  max! = math!(1)               'find min and max of integral
  min! = math!(1)               'to set plot window
  FOR i% = 1 TO preamble!(3)
   IF math!(i%)  max! THEN max! = math!(i%)
   IF math!(i%)  min! THEN min! = math!(i%)
  NEXT i%
  WINDOW (1, min!)-(preamble!(3), max!) 'set up proper scale
  COLOR 12
  FOR i% = 1 TO preamble!(3)    'plot integral
    PSET (i%, math!(i%))
  NEXT i%
END SUB
```

Another interesting exercise is to use the waveform data and the preamble information to calculate and plot the integral of the signal The voltage of each data point is calculated using the peamble and this voltage value is summed to compute the integral.

Waveform Data and Preamble

Sample data record with only 500 points of 8 bit data



The waveform data inside the oscilloscope can be transferred out in a variety of formats. The data is in a defined block format with a header specifying the length of the block. The block is terminated with a line feed character (ASCII character 10).

The data may be read from the oscilloscope in various formats as specified in the table below:

HP 54600A DATA FORMATS:

byte	8 bits with values between 0 and 255
word	16 bits with values between 0 and 255 (high byte is zero padded)
ASCII	same as word format, separated by commas
no data (hole)	is represented by 0

The format used is based partly on the application, throughput considerations, and language data structures. For example, the 8-bit format offers the best throughput as there is less data to be transferred across the bus. However, when writing in QuickBASIC, there is not a convenient 8-bit data structure (like the QuickC unsigned char structure) available, hence a word format was selected for the sample QuickBASIC program.

The HP 54600A family offers 8-bit data, even when averaging is used, but the word format is offered for compatibility with computer systems and languages. The high byte of the word data is zero padded.

The HP 54600A sends the data in a high byte/low byte order in word format. The HP 54600A offers a waveform:byteorder command that allows the byte order to be controlled.

Although the HP82335 HP-IB interface card offers DMA transfer, the overhead associated with setting up the DMA offsets performance improvements.

The data is in a representation used by the oscilloscope and NOT in terms of volts. For this reason, the preamble array is also read into the computer. The preamble array contains vertical and horizontal scaling information which can be used to convert the waveform data into volts and the data number into a corresponding time.

Preamble Array of 10 Real Numbers

1	format:	ASCII, byte, word, etc.
2	acquisition type:	normal, average, etc.
3	number of points acquired:	dependent on oscilloscope
4	count:	not used: always = 1
5	xincrement:	time between consecutive points
6	xorigin:	time of xreference
7	xreference.	time reference point: always 1st point on screen
8	yincrement:	voltage between consecutive points
9	yorigin:	voltage at yreference (center screen)
10	yreference:	voltage reference point: always at center screen

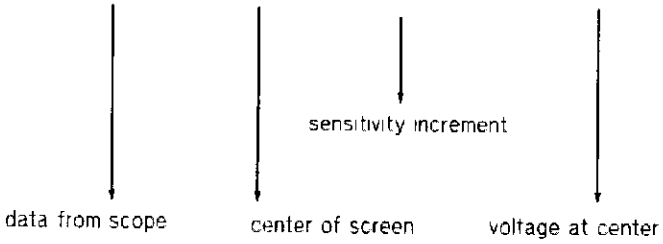
When referencing the elements in the preamble array, take care that the subscript reference scheme is correct. For example, the format in a C program will be referenced by preamble[0], but will be referenced in a BASIC program by preamble(1). Likewise, the yreference in a C program will be referenced by preamble[9], but it will be referenced in a BASIC program by preamble(10).

To convert the waveform data to volt/time pairs, two conversion formulas are necessary: one for conversion to volts and one for conversion to time. The preamble information as specified on the previous page provides the conversion values:

PREAMBLE INFORMATION

use preamble to convert waveform data to volts:

volts = (data value − yreference) yincrement + yorigin



Example of Conversion of Oscilloscope Data to Voltage

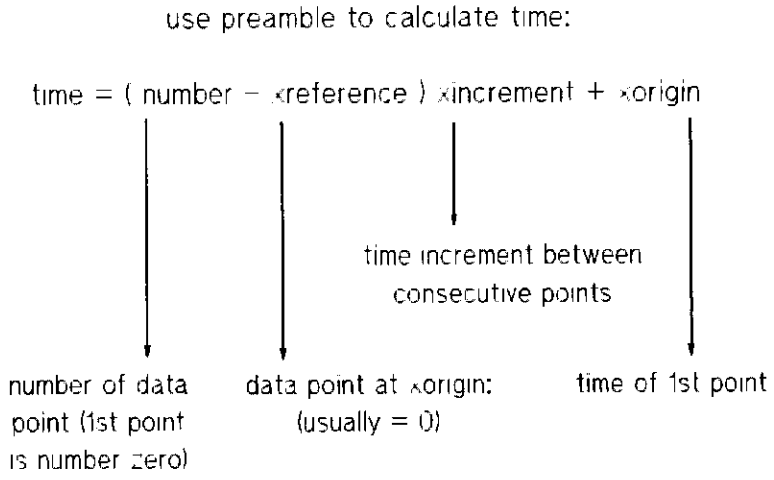
In reference to the formula above, the following calculates the voltage of the first data point in the waveform array:

in QuickC

```
voltage = (waveform[0] - preamble[9])*preamble[7] + preamble[8]
```

in QuickBASIC

```
voltage = (waveform%(1) - preamble !(10))*preamble!(8) + preamble!(9)
```


use preamble to calculate time:
time = (number − xreference) xincrement + xorigin
time increment between consecutive points
number of data point (1st point is number zero)
data point at xorigin: (usually = 0)
time of 1st point

Example Calculation of Data Point Time

In refernce to the above formula, use the following to calculate the time of the first data point in the waveform array:

in QuickC

```
time = (0 - preamble[6])*preamble[4]) + preamble[5]
```

in QuickBASIC

```
time =  (0 - preamble!(7))*preamble!(5) + preamble!(6)
```

Calculation of V/div, Offset, and s/div

There are three calculations in the graph function of the sample program that are dependent on the conversion formulas.

To calculate the vertical sensitivity (V/div), the increment value is multiplied by 32. The 32 is derived from the fact that there are 256 (0-255) vertical values spread across 8 divisions (256/8 = 32).

To calculate the offset, the center of the screen is defined as 128. The formula for conversion of oscilloscope data value to voltage is used with the data value being the center of the screen.

To calculate the horizontal sensitivity (s/div), multiply the time between consecutive points (xincrement) by the total number of points (number of points acquired), and divide by 10 for the ten divisions across the screen.

The formulas are different for QuickC and QuickBASIC. QuickC arrays are referenced from zero while QuickBASIC arrays are referenced from one

Errata

Title & Document Type: 54600/1/2/3B Oscilloscope User & Service Guide

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Revision Date: November 1997

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

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Agilent Technologies

User and Service Guide

Publication number 54600-97021
November 1997 (pdf version Nov 1998)

For Safety Information, Warranties, and Regulatory information, see the pages behind the index.

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HP 54600B, HP54601B, HP 54602B, and HP 54603B Oscilloscopes

General-Purpose Oscilloscopes

The HP 54600B-Series Oscilloscopes offer exceptional waveform viewing and measurements in a small, lightweight package. The two-channel HP 54600B and HP 54603B are suited for production, field service, and education applications. The four-channel HP 54601B is best suited for research and design labs, and applications involving digital circuit test and troubleshooting. For higher frequency applications, the HP 54602B provides 150 MHz bandwidth and triggering up to 250 MHz. Each of these oscilloscopes gives you:

- 60-MHz bandwidth (HP 54603B)
  100-MHz bandwidth (HP 54600B and HP 54601B)
  150-MHz bandwidth (HP 54602B)
- Automatic setup of the front panel
- Automatic and cursor measurements of frequency, time, and voltage
- Waveform storage
- Save and recall of 16 front-panel setups
- Peak detect

These oscilloscopes are easy to use with familiar controls and high display update rate, but with none of the viewing problems that are associated with analog oscilloscopes. A bright, crisp display is obtained at all sweep speeds and delayed sweep magnifications. Storage is as simple as pressing a button. Negative time allows the viewing of events that occur before the trigger event. Cursors and automatic measurements greatly simplify the analysis of these events.

You can upgrade this oscilloscope for hardcopy or remote control with the addition of an interface module. Unattended waveform monitoring and additional waveform math, such as FFT, can be added with the addition of one of the Measurement/Storage modules.

Bring your scope and PC together with BenchLink software. BenchLink, which runs under Windows, allows easy transfer of scope traces and waveform data to your PC for incorporation into documents or storage.

Accessories supplied

- Two 1.5 meter, 10:1 Probes (HP 10071A)
- Power cord for country of destination
- This *User and Service Guide*
- *Programmer's Guide* with Microsoft Windows Help file, ascii help file, and sample programs.

Accessories available

- HP 34810B BenchLink/Scope Software for Windows
- HP 54650A HP-IB Interface Module
- HP 54652A Parallel Interface Module
- HP 54654A Operator's Training Kit
- HP 54655A and HP 54656A Test Automation Modules
- HP 54657A HP-IB Measurement Storage Module
- HP 54659B Serial/Parallel Measurement/Storage Modules
- HP 5041-9409 Carrying Case
- HP 5062-7345 Rackmount Kit
- HP 10070A 1.5 meter, 1:1 Probe
- HP 10100C 50 Ω Termination

Options available

- Option 001 RS-03 Magnetic Interference Shielding Added to CRT
- Option 002 RE-02 Display Shield Added to CRT
- Option 005 Enhanced TV/Video Trigger (HP 54602B only)
- Option 090 Deletes Probes
- Option 101 Accessory Pouch and Front-Panel Cover
- Option 102 Two Additional HP 10071A 10:1 Probes (HP 54602B only)
- Option 103 Operator's Training Kit (HP 54654A)
- Option 104 Carrying Case (HP 5041-9409)
- Option 106 BenchLink/Scope Software (HP 34810B)
- Option 1CM Rackmount Kit (HP 5062-7345)
- Power Cords (see the table of Replaceable Parts at the end of Chapter 4, Service.)

In This Book

1 The Oscilloscope at a Glance

2 Operating Your Oscilloscope

3 Using Option 005 Enhanced TV/Video Trigger (HP 54602B)

4 Service

5 Performance Characteristics

Glossary

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This manual is the user and service guide for the HP 54600B, HP 54601B, HP 54602B, and HP 54603B Oscilloscopes, and contains five chapters.

First Time Users Chapter 1 is a quick start guide that gives you a brief overview of the oscilloscope.

Advanced users Chapter 2 is a series of exercises that guide you through the operation of the oscilloscope.

TV/Video triggering Chapter 3 shows how to use enhanced TV/Video triggering if you have Option 005 installed in your oscilloscope.

Service technicians Chapter 4 contains the service information for the oscilloscope. There are procedures for verifying performance, adjusting, troubleshooting, and replacing assemblies in the oscilloscope.

Reference information Chapter 5 lists the characteristics of the oscilloscope.

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Glossary

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1

The Oscilloscope at a Glance

The Oscilloscope at a Glance

One of the first things you will want to do with your new oscilloscope is to become acquainted with its front panel. Therefore, we have written the exercises in this chapter to familiarize you with some of its controls.

The front panel has knobs, grey keys, and white keys. The knobs are used most often and are similar to the knobs on other oscilloscopes. The grey keys bring up softkey menus on the display that allow you access to many of the oscilloscope features. The white keys are instant action keys and menus are not associated with them.

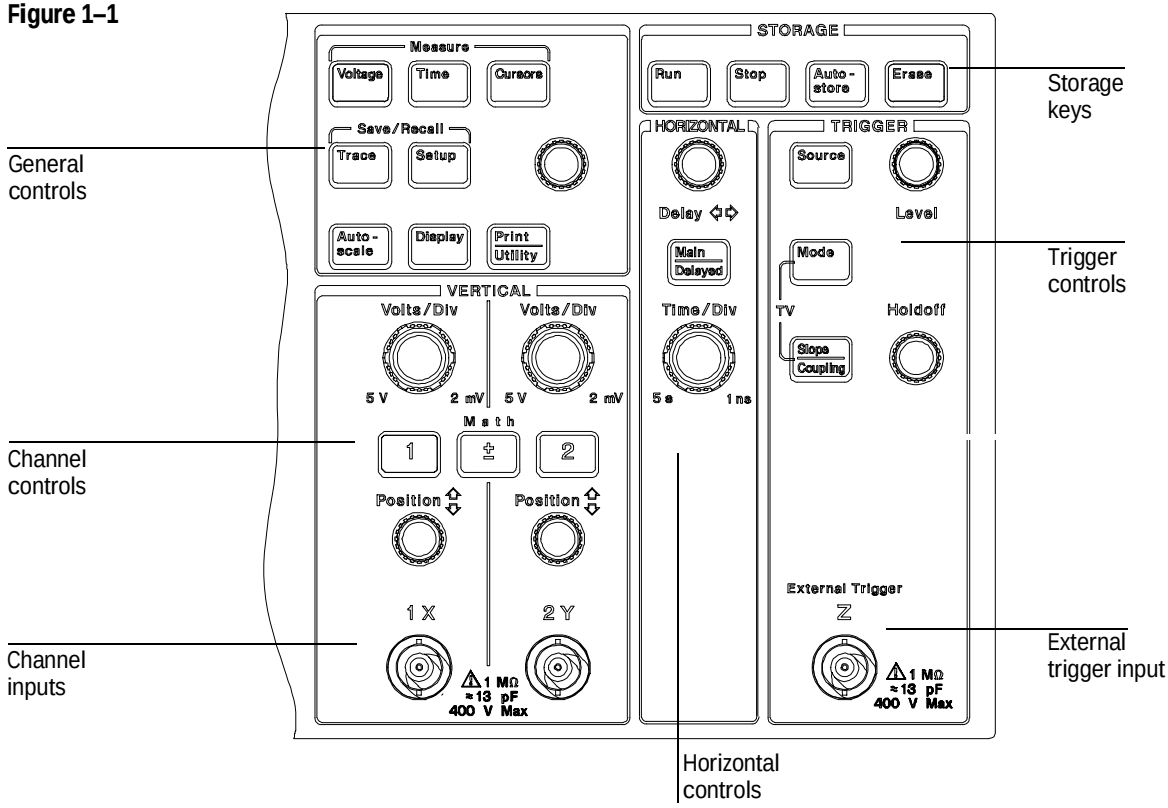
Throughout this book, the front-panel keys are denoted by a box around the name of the key, and softkeys are denoted by a change in the text type. For example, **Source** is the grey front-panel key labeled source under the trigger portion of the front panel, and **Line** is a softkey. The word **Line** is at the bottom of the display directly above an unlabeled softkey (which is also grey).

Figure 1-1 is a diagram of the front-panel controls and input connectors of the HP 54600B and HP 54603B. Figure 1-2 is a diagram of the front-panel controls and input connectors of the HP 54601B and HP 54602B.

Figure 1-3 is a status line example on the HP 54602B. The status line, located at the top of of the display, lets you quickly determine the setup of the oscilloscope. In this chapter you will learn to read at a glance the setup of the oscilloscope from the status line.

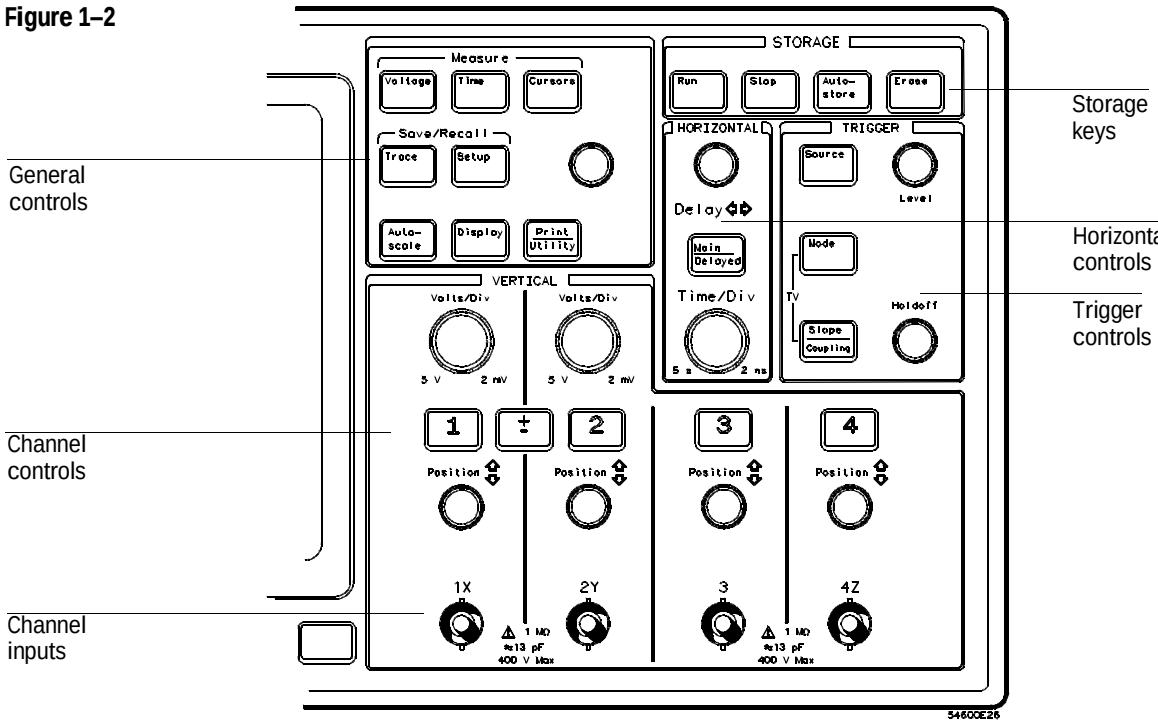
Figure 1-4 is a diagram showing which grey keys to press to bring up the various softkey menus.

Figure 1–1



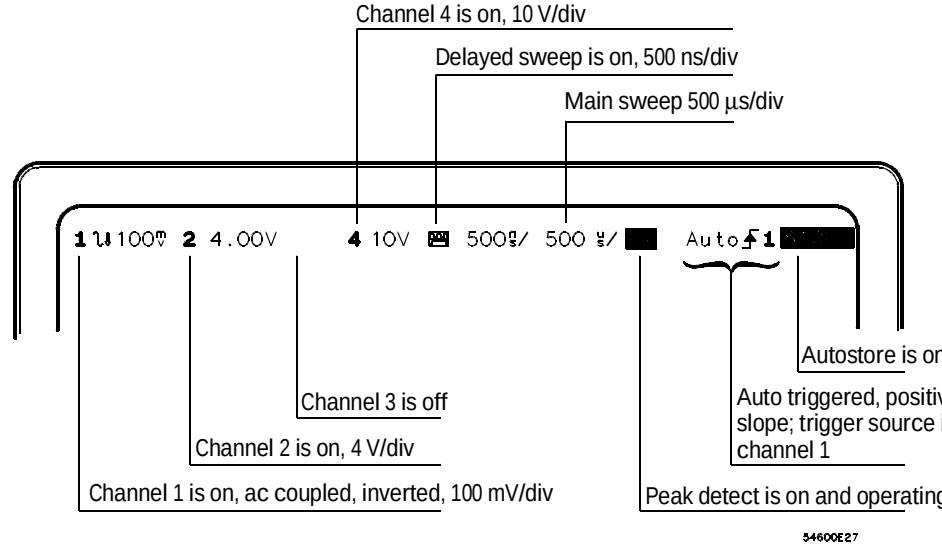
HP 54600B and HP 54603B Front Panel Controls

Figure 1–2



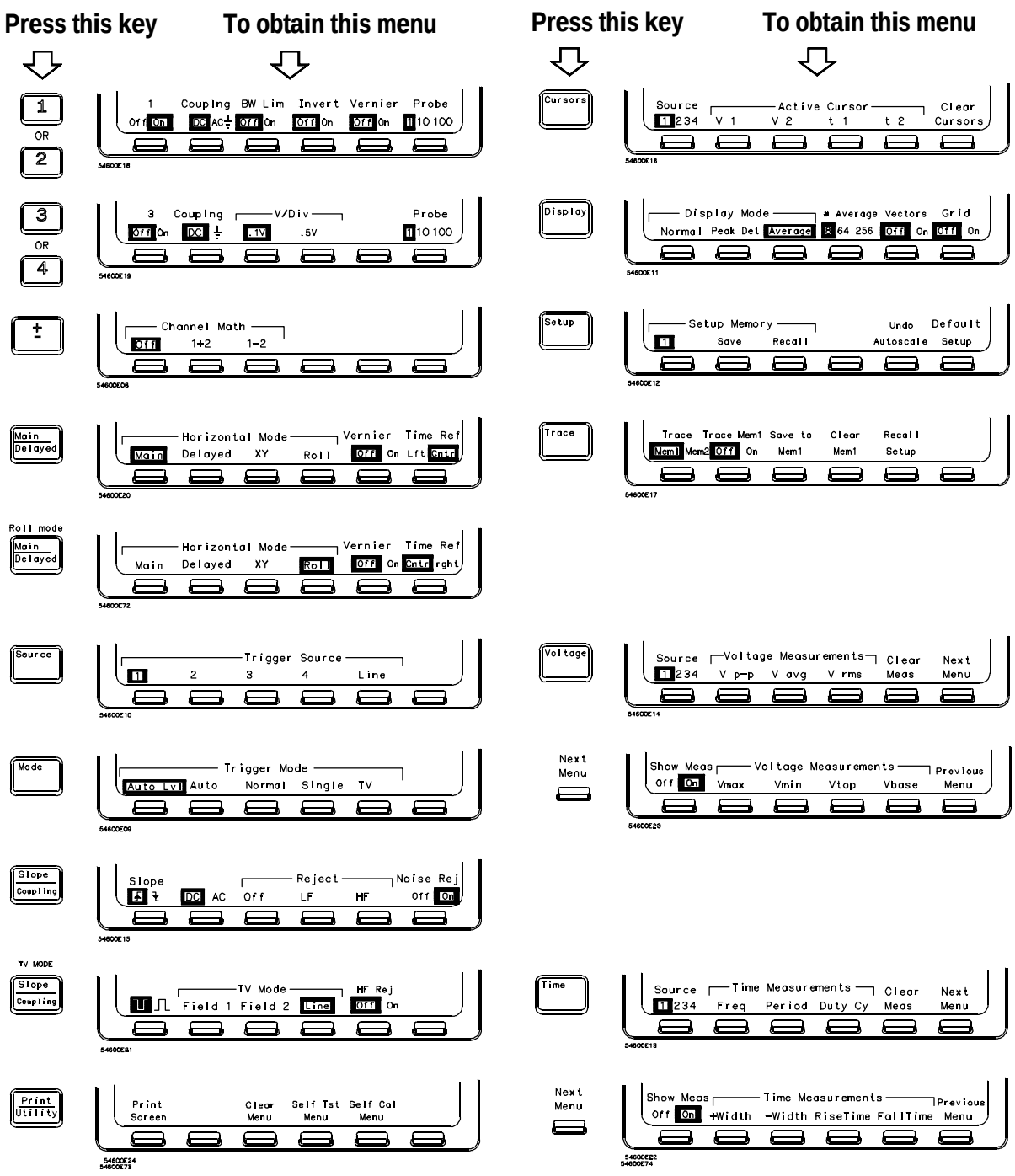
HP 54601B and HP 54602B Front Panel Controls

Figure 1–3


Channel 4 is on, 10 V/div
Delayed sweep is on, 500 ns/div
Main sweep 500 µs/div
1 100mV 2 4.00V 4 10V 500ns/ 500 µs/ Auto 1
Autostore is on
Auto triggered, positive slope; trigger source is channel 1
Channel 3 is off
Channel 2 is on, 4 V/div
Channel 1 is on, ac coupled, inverted, 100 mV/div
Peak detect is on and operating
54600E27

HP 54602B Display Status Line Indicators

Figure 1–4



Softkey Menu Reference

To inspect the instrument

☐ **Inspect the shipping container for damage.**

Keep a damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

☐ **Check the accessories.**

Accessories supplied with the instrument are listed in "Accessories Supplied" in the front of this manual.

- If the contents are incomplete or damaged notify your HP sales office.

☐ **Inspect the instrument.**

- If there is mechanical damage or defect, or if the instrument does not operate properly or pass performance tests, notify your HP sales office.
- If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your HP sales office. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement at Hewlett-Packard's option without waiting for claim settlement.

To clean the instrument

If this instrument requires cleaning, disconnect it from all power sources and clean it with a mild detergent and water. Make sure the instrument is completely dry before reconnecting it to a power source.

To connect a signal to the oscilloscope

The HP 54600B and HP 54603B are a two-channel oscilloscopes with an external trigger input, while the HP 54601B and HP 54602B are four-channel oscilloscopes. The four-channel oscilloscope replaces the external trigger input with channels 3 and 4. In this exercise you connect a signal to the channel 1 input.

To avoid damage to your new oscilloscope, make sure that the voltage level of the signal you are using is less than or equal to 400 V (dc plus the peak ac). For a complete list of the characteristics see chapter 5, "Performance Characteristics."

- Use a cable or a probe to connect a signal to channel 1.

  If you are using a probe, the oscilloscope allows you to enter the attenuation factor for the probe. The attenuation factor changes the vertical scaling of the oscilloscope so that the measurement results reflect the actual voltage levels at the probe tip.

- To set the probe attenuation factor press [1] . Next toggle the **Probe** softkey to change the attenuation factor to match the probe you are using.

You should compensate 10:1 probes to match their characteristics to the oscilloscope. A poorly compensated probe can introduce measurement errors. To compensate a probe, follow these steps.

1. Connect the 10:1 probe from channel 1 to the front-panel probe adjust signal on the oscilloscope.
2. Press `Autoscale` .
3. Use a nonmetallic tool to adjust the trimmer capacitor on the probe for the flattest pulse possible as displayed on the oscilloscope.

Figure 1–5

Overcompensation causes pulse peaking.

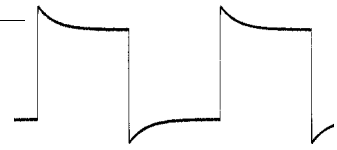


Figure 1–6

Correct compensation with a flat pulse top.

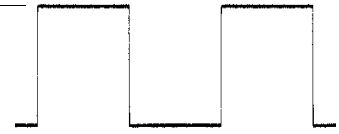


Figure 1–7

Undercompensation causes pulse rolloff.

To display a signal automatically

The oscilloscope has an Autoscale feature that automatically sets up the oscilloscope to best display the input signal. Using Autoscale requires signals with a frequency greater than or equal to 50 Hz and a duty cycle greater than 1%.

When you press the Autoscale key, the oscilloscope turns on and scales all channels that have signals applied, and it selects a time base range based on the trigger source. The trigger source selected is the highest numbered input that has a signal applied. (If a signal is connected to the external trigger input on the HP 54600B and HP 54603B, then it is selected as the trigger source.)

1 Connect a signal to the oscilloscope.

2 Press `Autoscale` .

When you press the Autoscale key, the oscilloscope changes the front-panel setup to display the signal. However, if you pressed the Autoscale key unintentionally, you can use the Undo Autoscale feature. To use this feature, perform the following step.

- Press `Setup` . Next, press the **Undo Autoscale** softkey.

  The oscilloscope returns to the configuration in effect before you pressed the Autoscale key.

To set up the vertical window

The following exercise guides you through the vertical keys, knobs, and status line.

1 Center the signal on the display with the Position knob.

The Position knob moves the signal vertically, and it is calibrated. Notice that as you turn the Position knob, a voltage value is displayed for a short time indicating how far the ground reference is located from the center of the screen. Also notice that the ground symbol on the right side of the display moves in conjunction with the Position knob.

Measurement hints

If the channel is dc coupled, you can quickly measure the dc component of the signal by simply noting its distance from the ground symbol.

If the channel is ac coupled, the dc component of the signal is removed allowing you to use greater sensitivity to display the ac component of the signal.

2 Change the vertical setup and notice that each change affects the status line differently.

You can quickly determine the vertical setup from the status line in the display.

- Change the vertical sensitivity with the Volts/Div knob and notice that it causes the status line to change. For channels 3 and 4 on the HP 54601B and HP 54602B, press 3 or 4 . Then use the softkeys to change the vertical sensitivity.
- Press 1 .

  A softkey menu appears on the display, and the channel turns on (or remains on if it was already turned on).
- Toggle each of the softkeys and notice which keys cause the status line to change.

  Channels 1 and 2 have a vernier softkey that allows the Volt/Div knob to change the vertical step size in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on.
- To turn the channel off, either press 1 a second time or press the left-most softkey.

Invert operating hint

When you are triggered on the signal you are inverting, the inversion also applies to the trigger signal (what was a rising edge now is a falling edge). If the signal has a 50% duty cycle (square wave or sine wave), the displayed waveform appears not to invert. However, for signals with a duty cycle other than 50%, the displayed waveform does invert as you would expect.

To set up the time base

The following exercise guides you through the time base keys, knobs, and status line.

1 Turn the Time/Div knob and notice the change it makes to the status line.

The Time/Div knob changes the sweep speed from 2 ns to 5 s in a 1-2-5 step sequence, and the value is displayed in the status line.

2 Change the horizontal setup and notice that each change affects the status line differently.

- Press **Main/Delayed** .

  A softkey menu appears on the display with six softkey choices.

- Toggle each of the softkeys and notice which keys cause the status line to change.

  There is also a horizontal vernier softkey that allows the Time/Div knob to change the sweep speed in smaller increments. These smaller increments are calibrated, which results in accurate measurements even with the vernier turned on.

- Turn the Delay knob and notice that its value is displayed in the status line.

  The Delay knob moves the main sweep horizontally, and it pauses at 0.00 s, mimicking a mechanical detent. At the top of the graticule is a solid triangle (▼) symbol and an open triangle (∇) symbol. The ▼ symbol indicates the trigger point and it moves in conjunction with the Delay knob. The ∇ symbol indicates the time reference point. If the time reference softkey is set to left, the ∇ is located one graticule in from the left side of the display. If the time reference softkey is set to center, the ∇ is located at the center of the display. The delay number tells you how far the reference point ∇ is located from the trigger point ▼.

  All events displayed left of the trigger point ▼ happened before the trigger occurred, and these events are called pretrigger information. You will find this feature very useful because you can now see the events that led up to the trigger point. Everything to the right of the trigger point ▼ is called posttrigger information. The amount of delay range (pretrigger and posttrigger information) available is dependent on the sweep speed selected. See "Horizontal System" in chapter 5 for more details.

To trigger the oscilloscope

The following exercise guides you through the trigger keys, knobs, and status line.

1 Turn the trigger Level knob and notice the changes it makes to the display.

On the HP 54601B and HP 54602B and on an internally triggered HP 54600B and HP 54603B, as you turn the Level knob or press a trigger menu key, for a short time two things happen on the display. First, the trigger level is displayed in inverse video. If the trigger is dc coupled, it is displayed as a voltage. If the trigger is ac coupled or if LF reject was selected, it is displayed as a percentage of the trigger range. Second, if the trigger source is turned on, a line is displayed showing the location of the trigger level (as long as ac coupling or low frequency reject are not selected).

2 Change the trigger setup and notice that each change affects the status line differently.

- Press **Source** .

  A softkey menu appears on the display showing the trigger source choices.

- Toggle each of the softkeys and notice that each key causes the status line to change.

- Press **Mode** .

  A softkey menu appears on the display with five trigger mode choices.

- Toggle the **Single** and **TV** softkeys and notice that they affect the status line differently. (You can only select TV if the trigger source is either channel 1 or 2.)

  When the oscilloscope is triggering properly, the trigger mode portion of the status line is blank.

What happens if the oscilloscope loses trigger?

If Auto Level is the trigger mode, Auto flashes in the status line. If dc coupled, the oscilloscope resets the trigger level to the center of the signal. If ac coupled, the oscilloscope resets the trigger level to the middle of the screen. (Every time you press the Auto Level softkey, the oscilloscope resets the trigger level.)

If Auto is the trigger mode, Auto flashes in the status line and the oscilloscope free runs.

If either Normal or TV is the trigger mode, the trigger setup flashes in the status line.

- Press **Slope/Coupling** .

  A softkey menu appears on the display. If you selected Auto level, Auto, Normal, or Single as a trigger mode, six softkey choices are displayed. If you selected TV as a trigger source, five other softkey choices are available.

- Toggle each of the softkeys and notice which keys affect the status line.

  On the HP 54600B and HP 54603B, external trigger is always dc coupled. If you select ac coupling or low frequency reject, these functions do not occur until you change the trigger source to channel 1, channel 2, or line.

3 Adjust the Holdoff knob and notice the change it makes to the display.

Holdoff keeps the trigger from rearming for an amount of time that you set with the Holdoff knob. Holdoff is often used to stabilize the complex waveforms. The Holdoff range is from 200.0 ns to about 13.5 s. It is displayed, for a short time, in inverse video near the bottom of the display.

To use roll mode

Roll mode continuously moves data across the display from right to left. It allows you to see dynamic changes (like adjusting a potentiometer) on low frequency signals. Two frequently used applications are transducer monitoring and power supply testing.

1. Press `Mode` . Then press the **Auto Lvl**, **Auto**, or **Normal** softkey.
2. Press `Main/Delayed` .
3. Press the **Roll** softkey.

   The oscilloscope is now untriggered and runs continuously. Also notice that the time reference softkey selection changes to center and right.
4. Press `Mode` . Then press the **Single** softkey.

   The oscilloscope fills either $\frac{1}{2}$ or $\frac{9}{10}$ of the display (depending on the time reference selection), then it searches for a trigger. After a trigger is found, the remainder of the display is filled. Then, the oscilloscope stops acquiring data.

   You can also make automatic measurements in the roll mode. Notice that the oscilloscope briefly interrupts the moving data while it makes the measurement. The acquisition system does not miss any data during the measurement. The slight shift in the display after the measurement is complete is that of the display catching up to the acquisition system.

Roll mode operating hints

- Roll mode operates on channels 1 and 2 only.
- Math functions, averaging, and peak detect are not available.
- Holdoff and horizontal delay do not affect the signal.
- Both a free running (nontriggered) display and a triggered display (available in the single mode only) are available.
- Roll mode is available at sweep speeds up to 200 ms.

Operating Your Oscilloscope

Operating Your Oscilloscope

By now you are familiar with the VERTICAL, HORIZONTAL, and TRIGGER groups of the front-panel keys. You should also know how to determine the setup of the oscilloscope by looking at the status line. If you are unfamiliar with this information, we recommend you read chapter 1, "The Oscilloscope at a Glance."

This chapter takes you through two new groups of front-panel keys: STORAGE, and the group of keys that contains the Measure, Save/Recall, and Display keys. You will also add to your knowledge of the HORIZONTAL keys by using delayed sweep.

We recommend you perform all of the following exercises so you become familiar with the powerful measurement capabilities of the oscilloscope.

To use delayed sweep

Delayed sweep is a magnified portion of the main sweep. You can use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (high resolution) analysis of signals. The following steps show you how to use delayed sweep. Notice that the steps are very similar to operating the delayed sweep in analog oscilloscopes.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press `Main/Delayed` .

3 Press the **Delayed** softkey.

The screen divides in half. The top half displays the main sweep, and the bottom half displays an expanded portion of the main sweep. This expanded portion of the main sweep is called the delayed sweep. The top half also has two solid vertical lines called markers. These markers show what portion of the main sweep is expanded in the lower half. The size and position of the delayed sweep are controlled by the Time/Div and Delay knobs. The Time/Div next to the symbol is the delayed sweep sec/div. The delay value is displayed for a short time at the bottom of the display.

- To display the delay value of the delayed time base, either press `Main/Delayed` or turn the Delay knob.
- To change the main sweep Time/Div, you must turn off the delayed sweep.

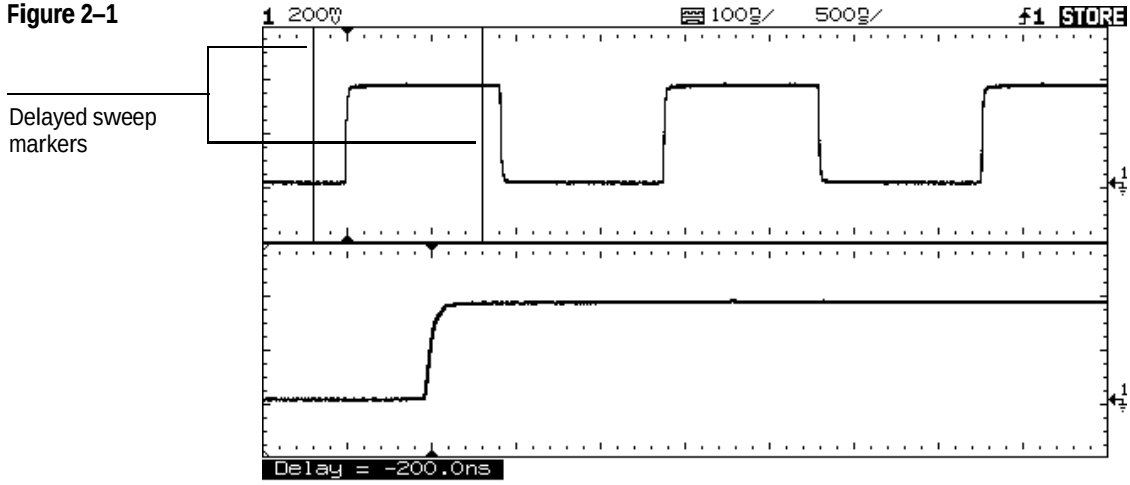
Since both the main and delayed sweeps are displayed, there are half as many vertical divisions so the vertical scaling is doubled. Notice the changes in the status line.

- To display the delay time of the delayed sweep, either press **Main/Delayed** or turn the delay knob. The delay value is displayed near the bottom of the display.

4 Set the **time reference** to either **left** or **center**.

Figure 2-1 shows the time reference set to left. The operation is like the delayed sweep of an analog oscilloscope, where the delay time defines the start of the delayed sweep.

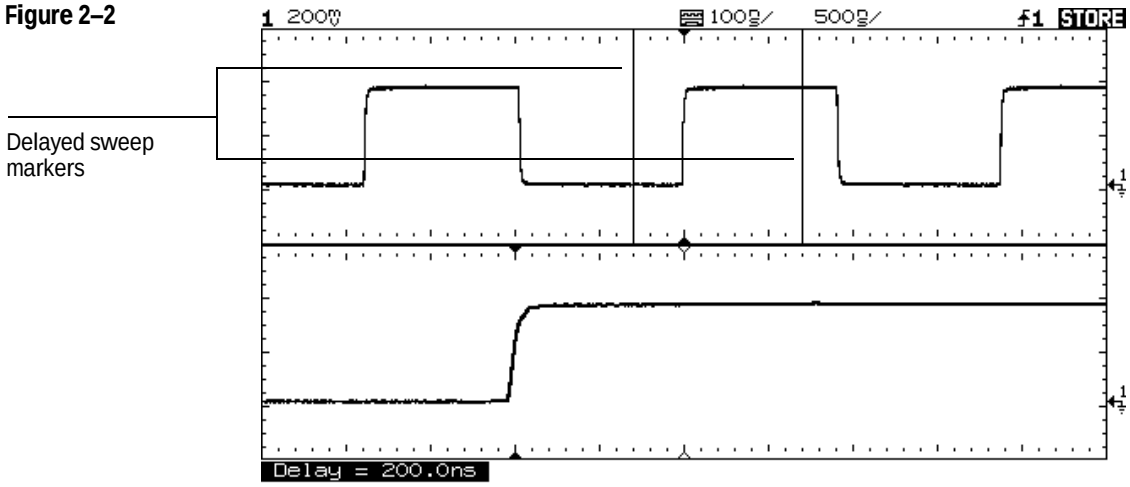
Figure 2–1



Time reference set to left

Figure 2-2 shows the time reference set to center. Notice that the markers expand around the area of interest. You can place the markers over the area of interest with the delay knob, then expand the delayed sweep with the time base knob to increase the resolution.

Figure 2–2



Time reference set to center

To use storage oscilloscope operation

There are four front-panel storage keys. They are white instant action keys that change the operating mode of the oscilloscope. The following steps demonstrate how to use these storage keys.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press `Autostore` .

Notice that **STORE** replaces **RUN** in the status line.

For easy viewing, the stored waveform is displayed in half bright and the most recent trace is displayed in full bright. Autostore is useful in a number of applications.

- Displaying the worst-case extremes of varying waveforms
- Capturing and storing a waveform
- Measuring noise and jitter
- Capturing events that occur infrequently

3 Using the position knob, move the trace up and down about one division.

Notice that the last acquired waveform is in full bright and the previously acquired waveforms are displayed in half bright.

- To characterize the waveforms, use the cursors. See "To make cursor measurements" on page 2–22.
- To clear the display, press **Erase** .
- To exit the Autostore mode, press either **Run** or **Autostore** .

Summary of storage keys

Run – The oscilloscope acquires data and displays the most recent trace.

Stop – The display is frozen.

Autostore – The oscilloscope acquires data, displaying the most recent trace in full bright and previously acquired waveforms in half bright.

Erase – Clears the display.

To capture a single event

To capture a single event, you need some previous knowledge of the signal in order to set up the trigger level and slope. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge. The following steps show you how to use the oscilloscope to capture a single event.

1. Connect a signal to the oscilloscope.
2. Set up the trigger.
   - Press **Source** . Select a trigger source with the softkeys.
   - Press **Slope/Coupling** . Select a trigger slope with the softkeys.
   - Turn the Level knob to a point where you think the trigger should work.
3. Press **Mode** , then press the **Single** softkey.
4. Press **Erase** to clear previous measurements from the display.
5. Press **Run** .

   Pressing **Run** arms the trigger circuit. When the trigger conditions are met, data appears on the display representing the data points that the oscilloscope obtained with one acquisition. Pressing the Run key again rearms the trigger circuit and erases the display.

6 If you need to compare several single-shot events, press **Autostore** .

Like the **Run** key, **Autostore** also arms the trigger circuit. When the trigger conditions are met, the oscilloscope triggers. Pressing **Autostore** again rearms the trigger circuit, but this time the display is not erased. All the data points are retained on the display in half bright with each trigger allowing you to easily compare a series of single-shot events.

After you have acquired a single-shot event, pressing a front-panel key, softkey, or changing a knob can erase the event from the display. If you press **Stop** , the oscilloscope will recover the event and restore the oscilloscope settings.

- To clear the display, press **Erase** .
- To exit the Autostore mode, press either **Run** or **Autostore** . Notice that **RUN** replaces **STORE** in the status line, indicating that the oscilloscope has exited the Autostore mode.

Operating hint

The single-shot bandwidth is 2 MHz for single-channel operation, and 1 MHz for two-channel operation. There are twice as many sample points per waveform on the one-channel acquisition than on the two-channel acquisition. On the HP 54600B and HP 54603B, channels 1 and 2 are captured simultaneously. On the HP 54601B and HP 54602B channels 1 and 2 are captured simultaneously, then on the next trigger channels 3 and 4 are captured simultaneously.

To capture glitches or narrow pulses

A glitch is a rapid change in the waveform that is usually narrow as compared to the waveform. This oscilloscope has two modes of operation that you can use for glitch capture: peak detect and Autostore.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Find the glitch.

Use peak detect for narrow pulses or glitches that require sweep speeds slower than 50 µs/div.

- To select peak detect, press **Display** . Next, press the **Peak Det** softkey.

  Peak detect operates at sweep speeds from 5 s/div to 50 µs/div. When operating, the initials Pk are displayed in the status line in inverse video. At sweep speeds faster than 50 µs/div, the Pk initials are not displayed in inverse video, which indicates that peak detect is not operating.

  Use Autostore for the following cases: waveforms that are changing, waveforms that you want to view and compare with stored waveforms, and narrow pulses or glitches that occur infrequently but require the use of sweep speeds outside the range of peak detect.

- Press **Autostore** .

  You can use peak detect and Autostore together. Peak detect captures the glitch, while Autostore retains the glitch on the display in half bright video.

3 Characterize the glitch with delayed sweep.

Peak detect functions in the main sweep only, not in the delayed sweep. To characterize the glitch with delayed sweep follow these steps.

- Press `Main/Delayed` . Next press the **Delayed** softkey.
- To obtain a better resolution of the glitch, expand the time base.
- To set the expanded portion of the main sweep over the glitch, use the Delay knob.
- To characterize the glitch, use the cursors or the automatic measurement capabilities of the oscilloscope.

To trigger on a complex waveform

The difficulty in viewing a complex waveform is triggering on the signal. Figure 2-3 shows a complex waveform that is not synchronized with the trigger.

The simplest trigger method is to trigger the oscilloscope on a sync pulse that is associated with the waveform. See "To trigger the oscilloscope" on page 1–14. If there is no sync pulse, use the following procedure to trigger on a periodic complex waveform.

1. Connect a signal to the oscilloscope.
2. Set the trigger level to the middle of the waveform.
3. Adjust the Holdoff knob to synchronize the trigger of the oscilloscope with the complex waveform.

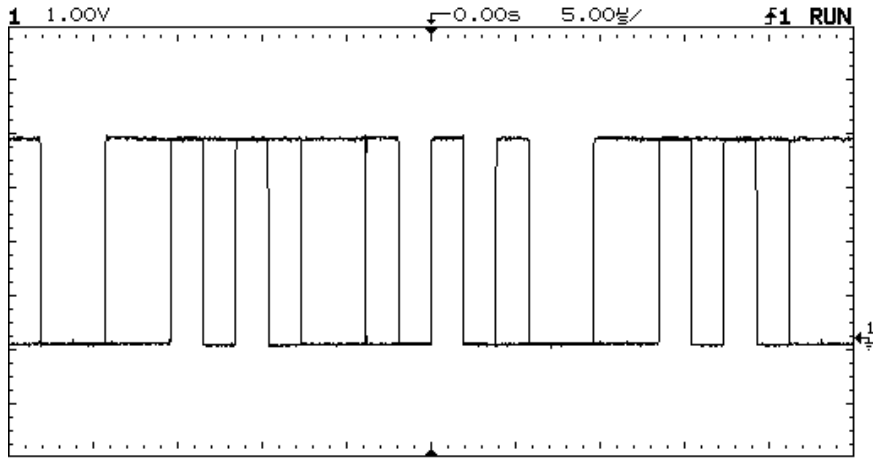
   By setting the Holdoff to synchronize the trigger, the oscilloscope ignores the trigger that results in figure 2-3, and waits for the trigger that results in figure 2-4. Also notice in figure 2-3 that the trigger is stable, but the waveform is not synchronized with the trigger.

Holdoff operating hints

1 The advantage of digital holdoff is that it is a fixed number. As a result, changing the time base settings does not affect the holdoff number; so, the oscilloscope remains triggered. In contrast, the holdoff in analog oscilloscopes is a function of the time base setting making it necessary to readjust the holdoff each time you change the time base setting.

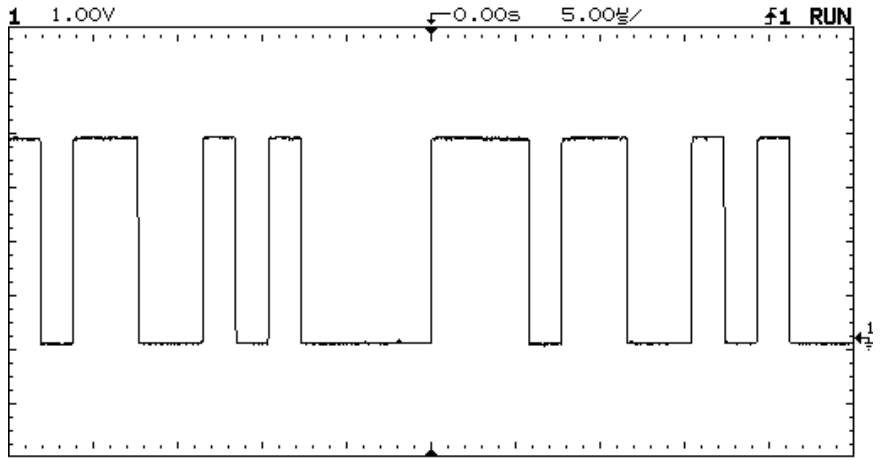
2 The rate of change of the holdoff adjustment knob depends on the time base setting you have selected. If you need a lengthy holdoff setting, increase the time/div setting on the time base, then make your coarse holdoff adjustment. Now switch back to the original time/div setting and make the fine adjustment to reach the exact amount you want.

Figure 2–3



Stable trigger, but the waveform is not synchronized with the trigger

Figure 2–4



Holdoff synchronizes the waveform with the trigger

In figure 2-4, the holdoff is set to about 25 µs (the duration of the pattern.)

To make frequency measurements automatically

The automatic measurement capability of the oscilloscope makes frequency measurements easy, as the following steps demonstrate.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press `Time` .

   A softkey menu appears with six softkey choices.
3. Toggle the **Source** softkey to select a channel for the frequency measurement.
4. Press the **Freq** softkey.

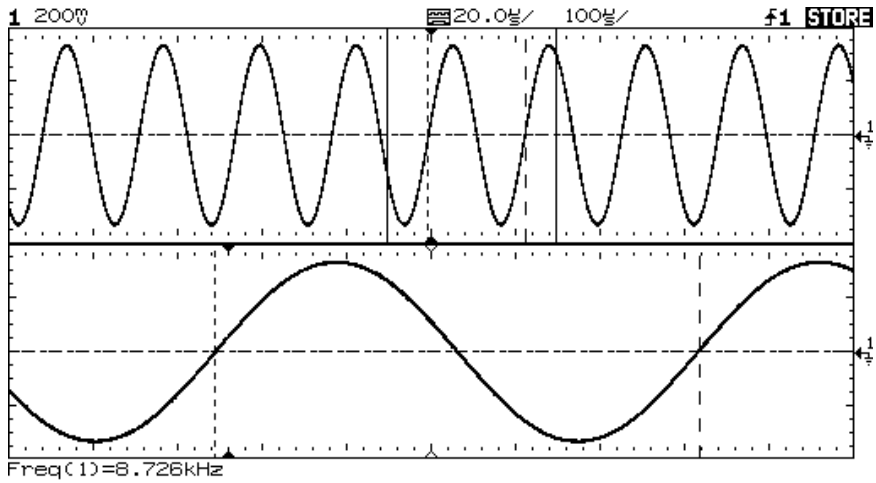
   The oscilloscope automatically measures the frequency and displays the result on the lower line of the display. The number in parentheses after the word **Freq** is the number of the channel that the oscilloscope used for the measurement. The oscilloscope retains in memory and displays the three most current measurement results. If you make a fourth measurement, the left-most result is dropped

If the **Show Meas** softkey is turned on, cursors are displayed on the waveform that show the measurement points for the right-most measurement result. If you select more than one measurement, you can show a previous measurement by reselecting the measurement.

- To find the **Show Meas** softkey, press the **Next Menu** softkey key.

  The oscilloscope makes automatic measurements on the first displayed event. Figure 2-5 shows how to use delayed sweep to isolate an event for a frequency measurement. If the measurement is not possible in the delayed time base mode, then the main time base is used. If the waveform is clipped, it may not be possible to make the measurement.

Figure 2–5



Delayed time base isolates an event for a frequency measurement

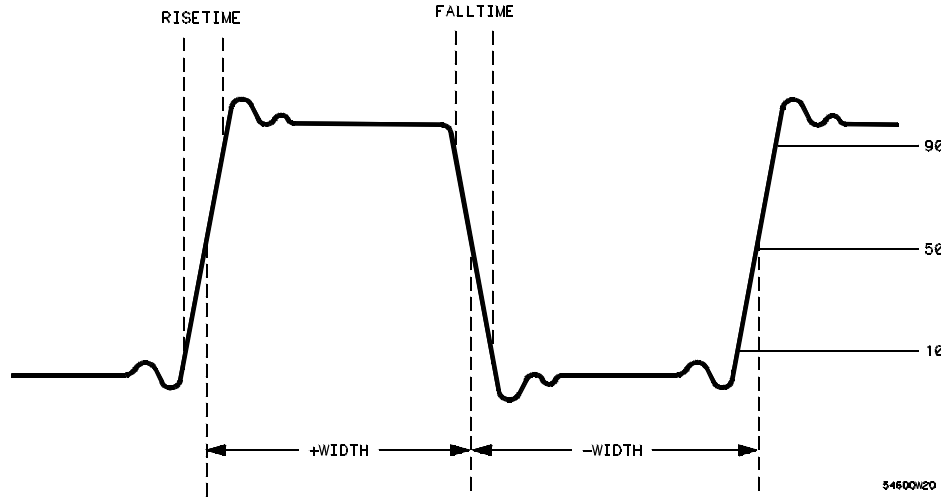
To make time measurements automatically

You can measure the following time parameters with the oscilloscope: frequency, period, duty cycle, width, rise time, and fall time. The following exercise guides you through the Time keys by making a rise time measurement. Figure 2-6 shows a pulse with some of the time measurement points.

1 Connect a signal to the oscilloscope and obtain a stable display.

When the signal has a well-defined top and bottom (see figure 2-8), the rise time and fall time measurements are made at the 10% and 90% levels. If the oscilloscope cannot find a well-defined top or bottom (see figure 2-9), the maximum and minimum levels are used to calculate the 10% and 90% points.

Figure 2–6



Time Measurement Points

2 Press Time .

A softkey menu appears with six softkey choices. Three of the softkeys are time measurement functions.

Source Selects a channel for the time measurement.

Time Measurements Three time measurement choices are available: Freq (frequency), Period, and Duty Cy (duty cycle). These measurements are made at the 50% levels. Refer to figure 2-6.

Clear Meas (clear measurement) Erases the measurement results and removes the cursors from the display.

Next Menu Replaces the softkey menu with six additional softkey choices.

3 Press the **Next Menu** softkey.

Another time measurement softkey menu appears with six additional choices. Four of the softkeys are time measurement functions.

Show Meas (show measurement) Displays the horizontal and vertical cursors where the measurement was taken.

Time **Measurements** Four additional time measurement choices are available; +Width, –Width, Rise time, and Fall time. Width measurements are made at the 50% levels, whereas rise time and fall time measurements are made at the 10% to 90% levels.

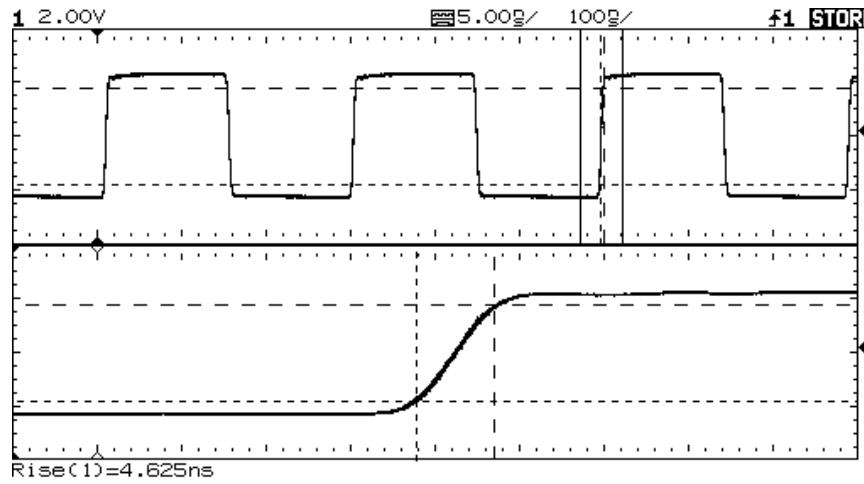
Previous Menu Returns to the previous softkey menu.

4 Press the **Rise Time** softkey.

The oscilloscope automatically measures the rise time of the signal and displays the result on the display.

The oscilloscope makes automatic measurements on the first displayed event. Figure 2-7 shows how to use delayed sweep to isolate an edge for a rise time measurement.

Figure 2–7

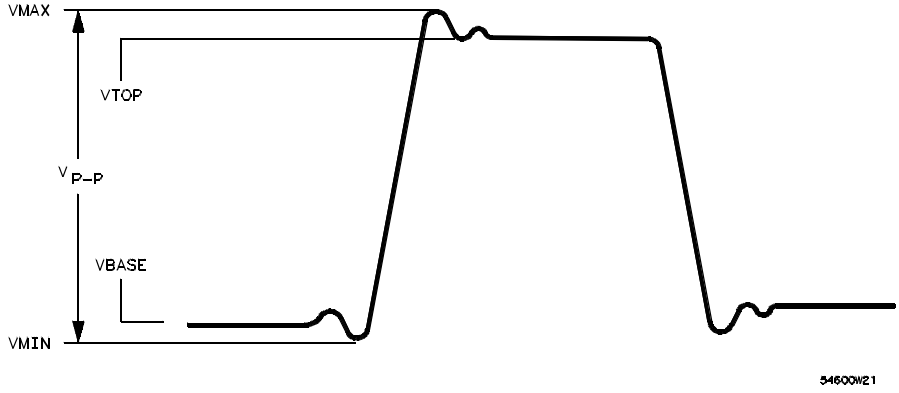


Delayed sweep isolates a leading edge for a rise time measurement

To make voltage measurements automatically

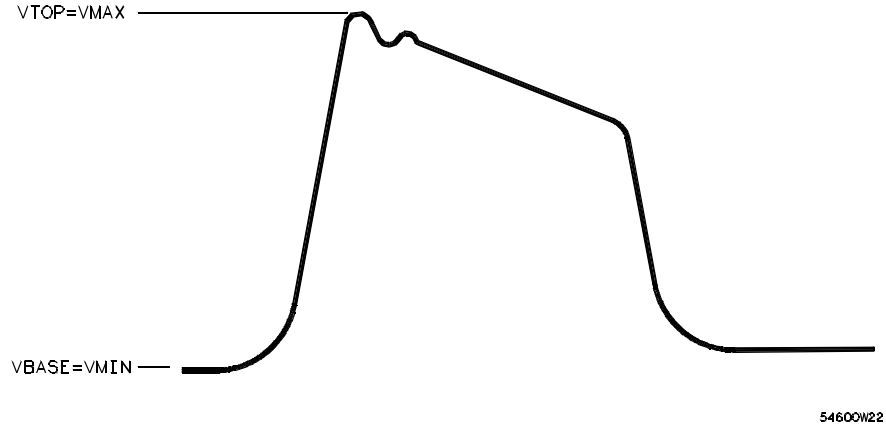
You can measure the following voltage parameters automatically with the oscilloscope: peak-to-peak, average, rms, maximum, minimum, top, and base. The following exercise guides you through the Voltage keys by making an rms voltage measurement. Figures 2-8 and 2-9 show pulses with some of the voltage measurement points.

Figure 2–8



Pulse where the top and bottom are well-defined

Figure 2–9



Pulse where the top and bottom are not well-defined

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press Voltage .

A softkey menu appears with six softkey choices. Three of the softkeys are voltage measurement functions.

Source Selects a channel for the voltage measurement.

Voltage Measurements Three voltage measurement choices are available: $V_{p\text{-}p}$, V_{avg}, and V_{rms}. The measurements are determined by voltage histograms of the signal.

Clear Meas (clear measurement) Erases any measurement results from the display, and removes the horizontal and vertical cursors from the display.

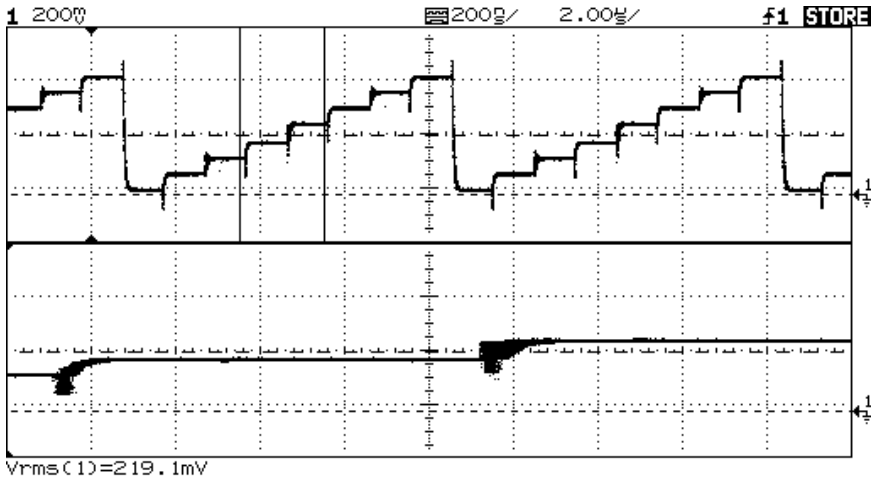
Next Menu Replaces the softkey menu with six additional softkey choices.

3 Press the **V_{rms}** softkey.

The oscilloscope automatically measures the rms voltage and displays the result on the display.

The oscilloscope makes automatic measurements on the first pulse or period in the display. Figure 2-10 shows how to use delayed sweep to isolate a pulse for an rms measurement.

Figure 2–10



Delayed sweep isolates an area of interest for an rms voltage measurement

4 Press the **Next Menu** softkey.

Another voltage measurement softkey menu appears with six additional choices. Four of the softkeys are voltage measurement functions.

Show Meas (show measurement) Displays the horizontal and vertical cursors that show where the measurement was taken on the signal.

Voltage Measurements Four additional voltage measurement choices are available: V_{max}, V_{min}, V_{top}, V_{base}.

Previous Menu Returns to the previous softkey menu.

To make cursor measurements

The following steps guide you through the front-panel **Cursors** key. You can use the cursors to make custom voltage or time measurements on the signal. Examples of custom measurements include rise time measurements from reference levels other than 10-90%, frequency and width measurements from levels other than 50%, channel-to-channel delay measurements, and voltage measurements. See figures 2-11 through 2-16 for examples of custom measurements.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press **Cursors** .

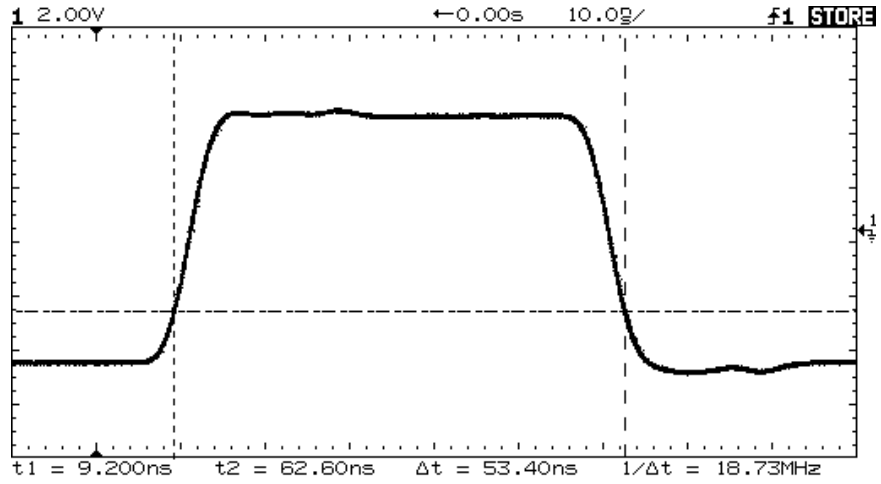
A softkey menu appears with six softkey choices. Four of the softkeys are cursor functions.

Source Selects a channel for the voltage cursor measurements.

Active Cursor There are four cursor choices: V1, and V2 are voltage cursors, while t1, and t2 are time cursors. Use the knob below the Cursors key to move the cursors. When you press the V1 and V2 softkeys simultaneously or the t1 and t2 softkeys simultaneously, the cursors move together.

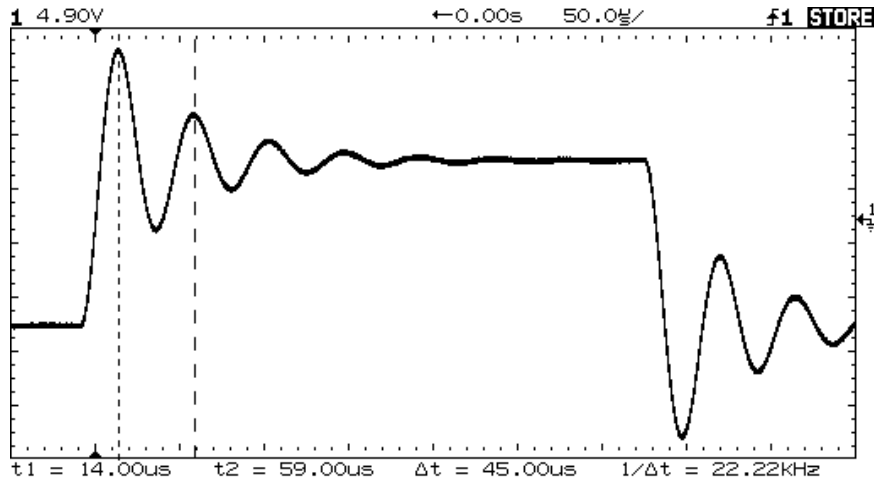
Clear Cursors Erases the cursor readings and removes the cursors from the display.

Figure 2–11



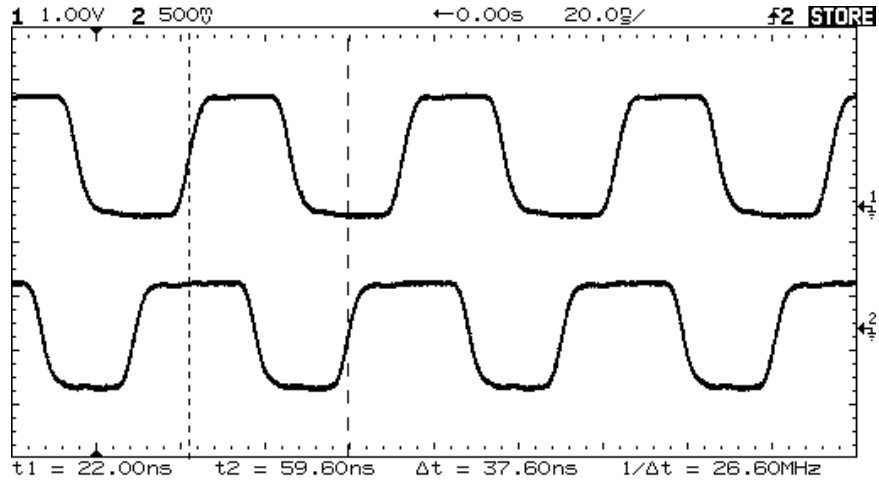
Cursors used to measure pulse width at levels other then the 50% points

Figure 2–12



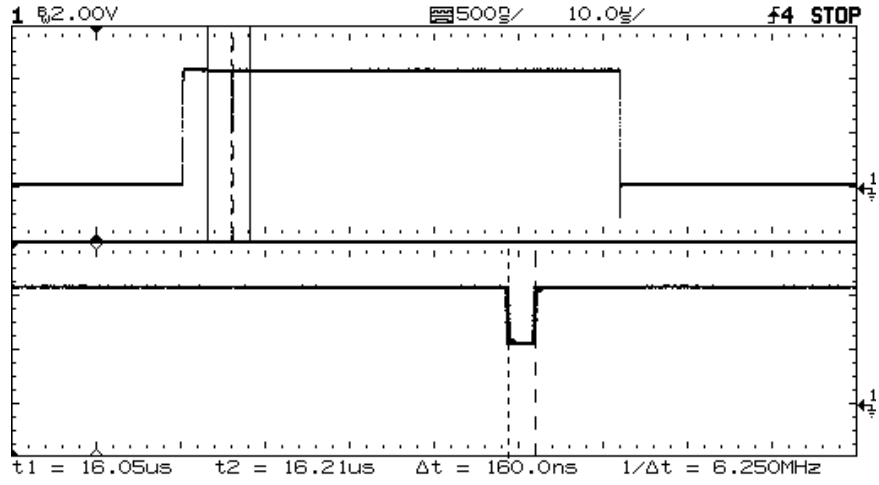
Cursors used to measure the frequency of the ringing on a pulse

Figure 2–13



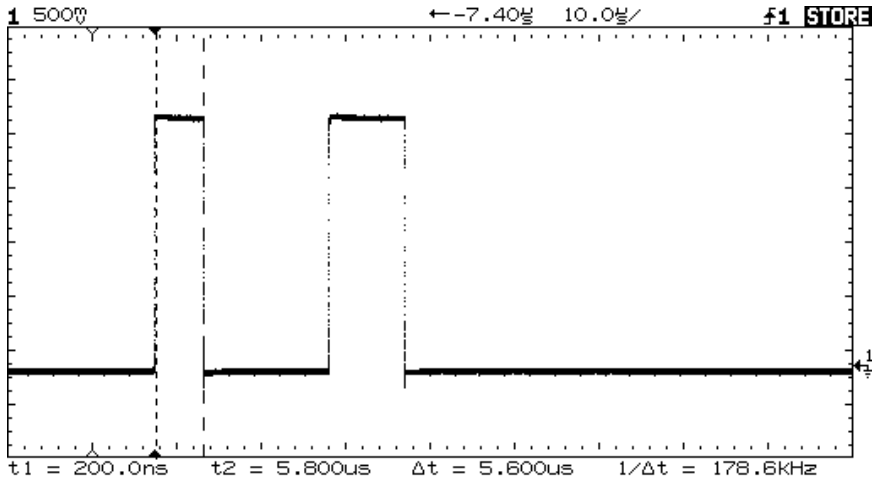
Cursors used to make channel-to-channel delay measurements

Figure 2–14



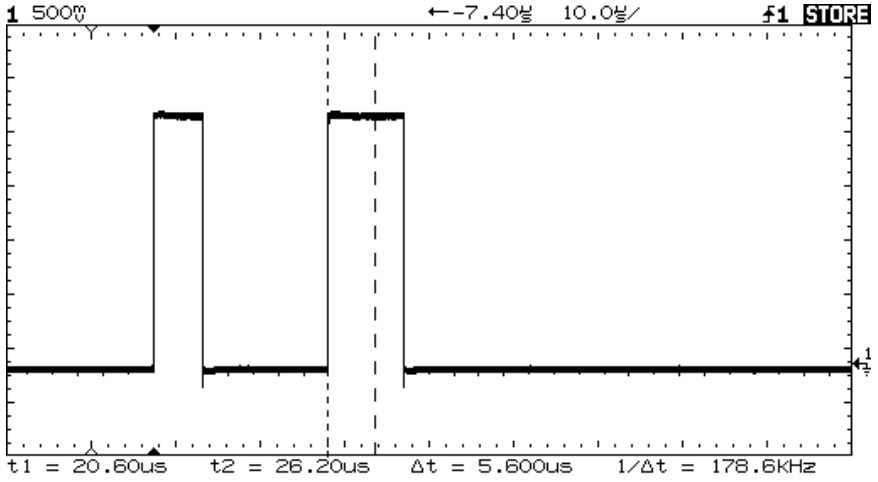
The cursors track delayed sweep. Expand the display with delayed sweep, then characterize the event of interest with the cursors.

Figure 2–15



Pressing t1 and t2 softkeys simultaneously causes the cursors to move together when the cursor knob is adjusted.

Figure 2–16



By moving the cursors together, you can check for pulse width variations in a pulse train, as figures 2-15 and 2-16 show.

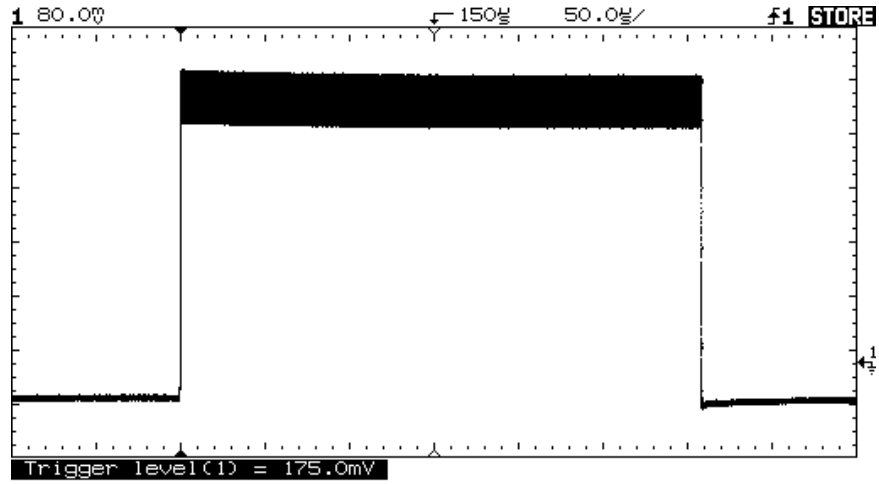
To view asynchronous noise on a signal

The following exercise shows how to use the oscilloscope to view asynchronous noise on a signal that is not synchronous to the period of the waveform.

1 Connect a noisy signal to the oscilloscope and obtain a stable display.

Figure 2-17 shows a waveform with asynchronous noise at the top of the pulse.

Figure 2–17



Asynchronous noise at the top of the pulse

2 Press **Autostore** .

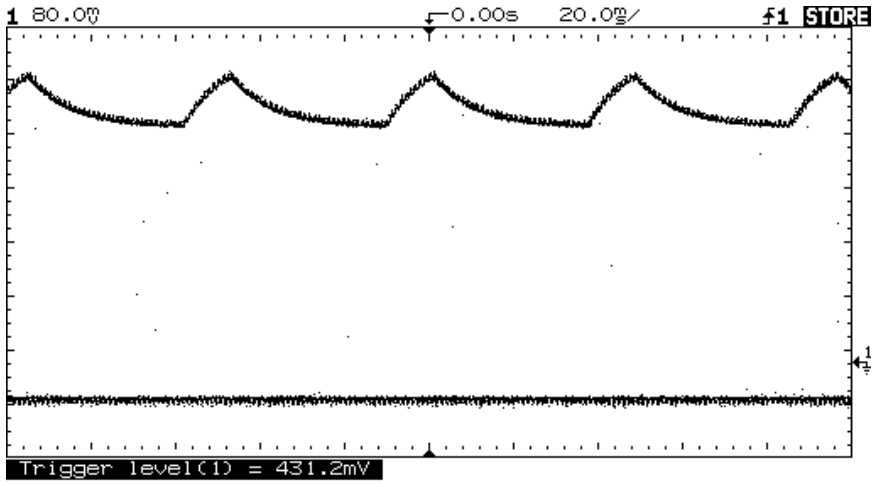
Notice that **STORE** is displayed in the status line.

3 Set the trigger mode to normal, then adjust the trigger level into the noise region of the signal.

4 Decrease the sweep speed for better resolution of the asynchronous noise.

- To characterize the asynchronous noise signal, use the cursors.

Figure 2–18



This is a triggered view of the asynchronous noise shown in Figure 2-17

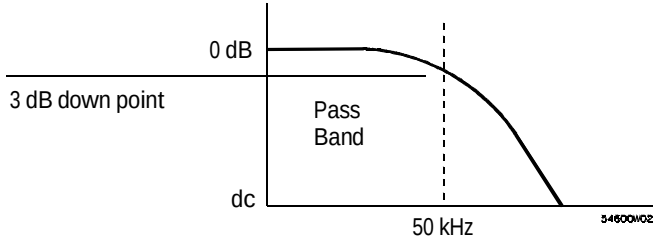
To reduce the random noise on a signal

If the signal you are applying to the oscilloscope is noisy (figure 2-21), you can set up the oscilloscope to reduce the noise on the waveform (figure 2-22). First, you stabilize the displayed waveform by removing the noise from the trigger path. Second, you reduce the noise on the displayed waveform.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Remove the noise from the trigger path by turning on either high frequency reject or noise reject.

   High frequency reject (HF reject) adds a low pass filter with the 3 dB point at 50 kHz (see figure 2-19). You use HF reject to remove high frequency noise such as AM or FM broadcast stations from the trigger path.

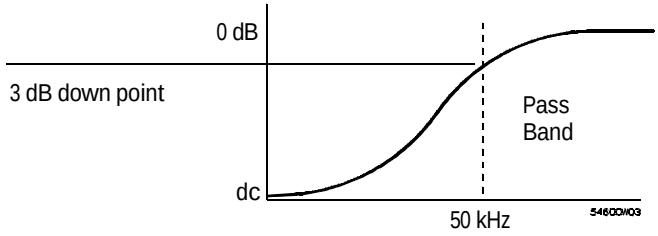
Figure 2–19



HF reject

Low frequency reject (LF reject) adds a high pass filter with the 3-dB point at 50 kHz (see figure 2-20). Use LF reject to remove low frequency signals such as power line noise from the trigger path.

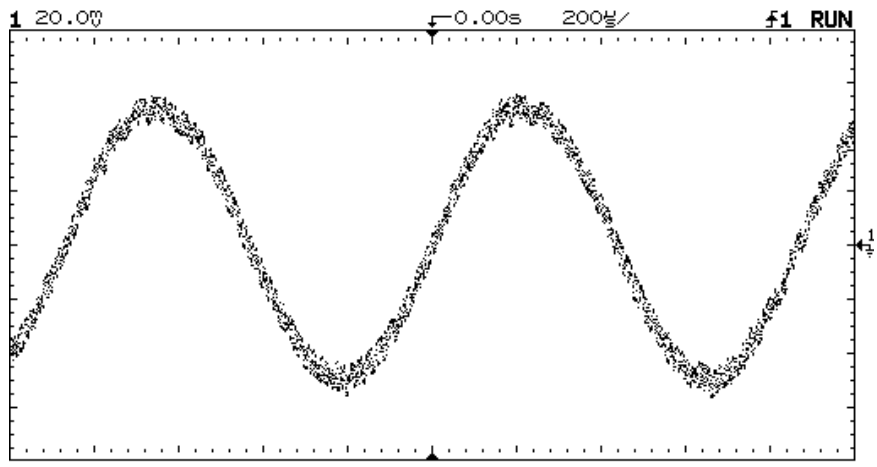
Figure 2–20



LF reject

Noise reject increases the trigger hysteresis band. By increasing the trigger hysteresis band you reduce the possibility of triggering on noise. However, this also decreases the trigger sensitivity so that a slightly larger signal is required to trigger the oscilloscope.

Figure 2–21



Random noise on the displayed waveform

3 Use averaging to reduce noise on the displayed waveform.

To use averaging follow these steps.

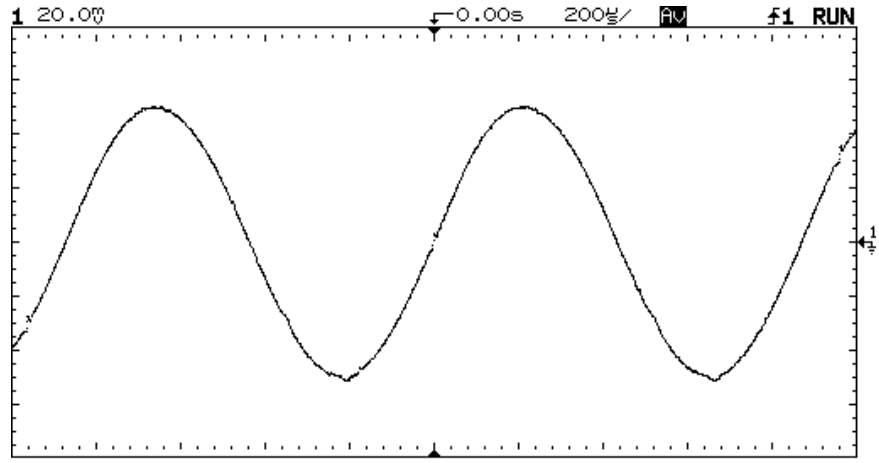
- Press **Display** , the press the **Average** softkey.

  Notice that Av appears in the status line.

- Toggle the **# Average** softkey to select the number of averages that best eliminates the noise from the displayed waveform.

  The Av initials in the status line indicates how much of the averaging process is finished, by turning to inverse video as the oscilloscope performs averaging. The higher the number of averages, the more noise that is removed from the display. However, the higher the number of averages, the slower the displayed waveform responds to waveform changes. You need to choose between how quickly the waveform responds to changes and how much noise there is on the signal.

Figure 2–22



On this waveform, 256 averages were used to reduce the noise

To save or recall traces

The oscilloscope has two pixel memories for storing waveforms. The following exercise guides you through how to store and recall waveforms from pixel memories.

1. Connect a signal to the oscilloscope and obtain a stable display.
2. Press Trace.

   A softkey menu appears with five softkey selections. Four of the softkeys are trace memory functions.

   Trace Selects memory 1 or memory 2.

   Trace Mem Turns on or off the selected memory.

   Save to Saves the waveform to the selected memory. The front-panel setup is saved to a separate memory location.

   Clear Erases the selected memory.

   Recall Setup Recalls the front-panel setup that was saved with the waveform.
3. Toggle the **Trace** softkey to select memory 1 or memory 2.
4. Press the **Save to** softkey.

   The current display is copied to the selected memory.
5. Turn on the **Trace Mem** softkey to view the stored waveform.

   The trace is copied from the selected trace memory and is displayed in half bright video.

The automatic measurement functions do not operate on stored traces. Remember, the stored waveforms are pictorial information rather than stored data.

- If you have not changed the oscilloscope setup, use the cursors to make the measurements.
- If you have changed the oscilloscope setup, press the **Recall Setup** softkey. Then,use the cursors to make the measurements.

Trace memory operating hint

The standard oscilloscope has volatile trace memories. When you add an interface module to the oscilloscope, the trace memories become nonvolatile.

To save or recall front-panel setups

There are 16 memories for storing front-panel setups. Saving front-panel setups can save you time in situations where several setups are repeated many times.

1 Press `Setup` .

2 To change the selected memory location, press either the left-most softkey or turn the knob closest to the Cursors key.

3 Press the **Save** softkey to save a front-panel setup, then press the **Recall** softkey to recall a front-panel setup.

To reset the instrument setup

1. To reset the instrument to the default factory-preset configuration, press `Setup` .
2. Press the **Default Setup** softkey.
3. To reset the instrument to the configuration that was present before pressing **Autoscale**, press the **Undo Autoscale** softkey.

Table 2-1

Default Setup configuration settings

Configuration Item	Setting
Cursors	Cursors off; time readout is selected; all cursors are set to time/voltage zero.
Trace memories	Both trace memory 1 and 2 are off; trace 1 memory is selected.
Setup memories	Setup memories are off; setup memory 1 is selected.
Graticule	Grid set to Full
Autostore	Off
Time base	Time reference center; main, not delayed sweep; main and delay value 0; 100 µs/div main time base.
Display	Vectors On, Display Mode Normal.
Channels	Channel 1 on, Position 0 V, Volts/Div 100 mV.
Trigger Mode	Auto Level, Coupling DC, Reject Off, Noise Reject Off.
Trigger Condition	Rising edge of channel 1

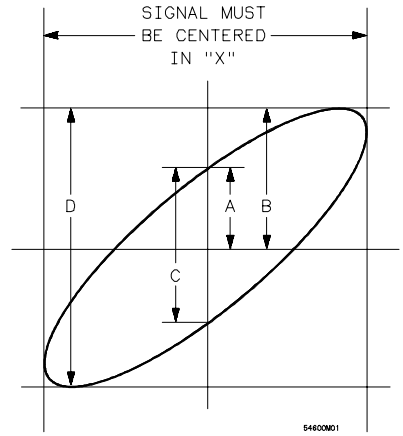
To use the XY display mode

The XY display mode converts the oscilloscope from a volts versus time display to a volts versus volts display. You can use various transducers so the display could show strain versus displacement, flow versus pressure, volts versus current, or voltage versus frequency. This exercise shows a common use of the XY display mode by measuring the phase shift between two signals of the same frequency with the Lissajous method.

1. Connect a signal to channel 1, and a signal of the same frequency but out of phase to channel 2.
2. Press **Autoscale** , press **Main/Delayed** , then press the **XY** softkey.
3. Center the signal on the display with the Position knobs, and use the Volts/Div knobs and the vertical **Vernier** softkeys to expand the signal for convenient viewing.

$\sin \theta = \frac{A}{B}$ *or* $\frac{C}{D}$, where θ = phase shift (in degrees) between the two signals.

Figure 2–23



Phase shift Parameters

XY display mode operating hint

Before entering XY display mode, center both channels on screen in the main sweep and adjust sweep speed to obtain greater than or equal to 1 cycle of the lowest frequency input signal on screen.

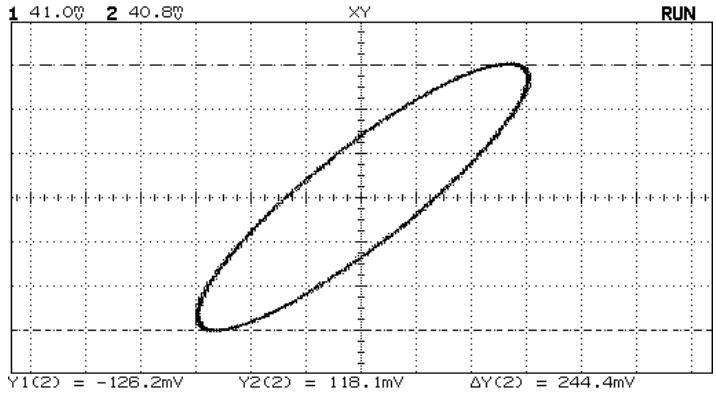
When you select the XY display mode, the time base is turned off. Channel 1 is the X-axis input, channel 2 is the Y-axis input, and channel 4 (external trigger in the HP 54600B and HP 54603B) is the Z-axis input. If you only want to see portions of the Y versus X display, use the Z-axis input. Z-axis turns on and off the trace (analog oscilloscopes called this Z-blanking because it turned the beam on and off). When Z is low (<1.3 V), Y versus X is displayed; when Z is high (>1.3 V), the trace is turned off.

4 Press **Cursors** .

5 Set the Y2 cursor to the top of the signal, and set Y1 to the bottom of the signal.

Note the ΔY value at the bottom of the display. In this example we are using the Y cursors, but you could have used the X cursors instead. If you use the X cursors, make sure you center the signal in the Y axis.

Figure 2–24

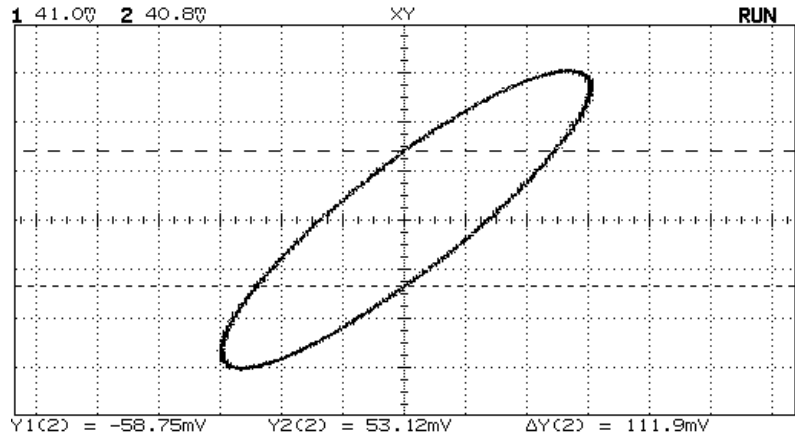


XY Display with Cursors On

6 Move the Y1 and Y2 cursors to the center of the signal.

Again, note the ΔY value.

Figure 2–25

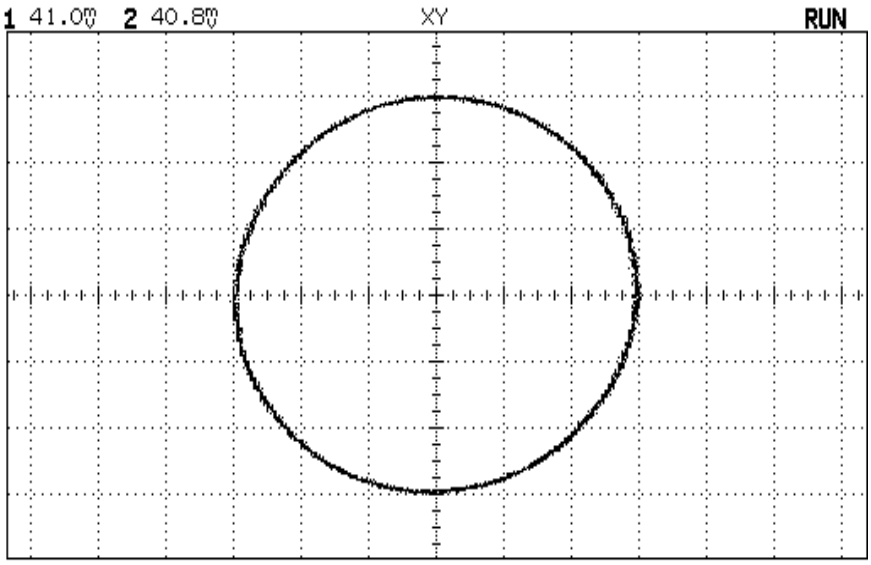


Y cursors centered

7 Calculate the phase difference using formula below.

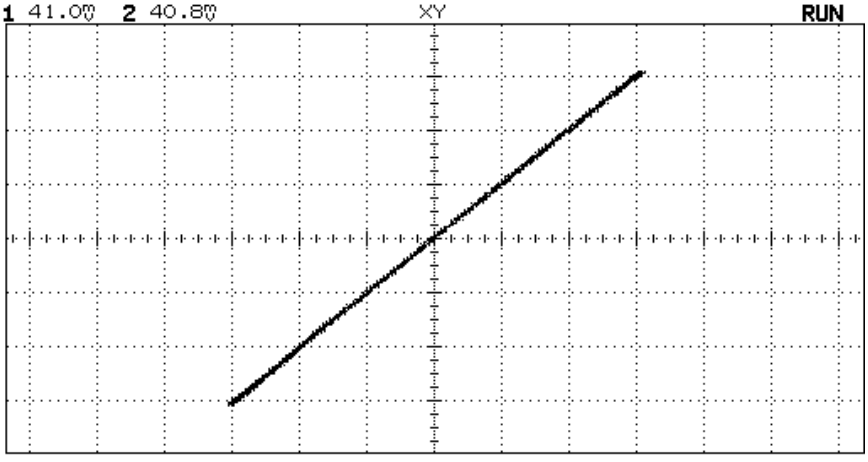
$$\sin\theta = \frac{second\ \Delta Y}{first\ \Delta Y} = \frac{111.9}{244.4} = 27.25 \text{ degrees of phase shift.}$$

Figure 2–26



Signals are 90° out of phase

Figure 2–27



Signals are in phase

To analyze video waveforms

Enhanced TV/Video Trigger (HP 54602B only)

This section discusses basic TV video triggering. If you have Option 005 Enhanced TV/Video Trigger installed in your HP 54602B oscilloscope, refer to Chapter 3 "Using Option 005 Enhanced TV/Video Trigger."

The TV sync separator in the oscilloscope has an internal clamp circuit. This removes the need for external clamping when you are viewing unclamped video signals. TV triggering requires two vertical divisions of display, either channel 1 or channel 2 as the trigger source, and the selection of internal trigger. Turning the trigger level knob in TV trigger does not change the trigger level because the trigger level is automatically set to the sync pulse tips.

For this exercise we connected the oscilloscope to the video output terminals on a television. Then we set up the oscilloscope to view these parts of a TV signal: the second vertical interval with delayed sweep windowed on the vertical interval test signals (VITS) and the IRE displayed full screen.

1. Connect a TV signal to channel 1, then press `Autoscale` .
2. Press `Display` , then press the **Peak Det** softkey.
3. Press `Mode` , then press the **TV** softkey.
4. Press `Slope/Coupling` , then press the **Field 2** softkey.

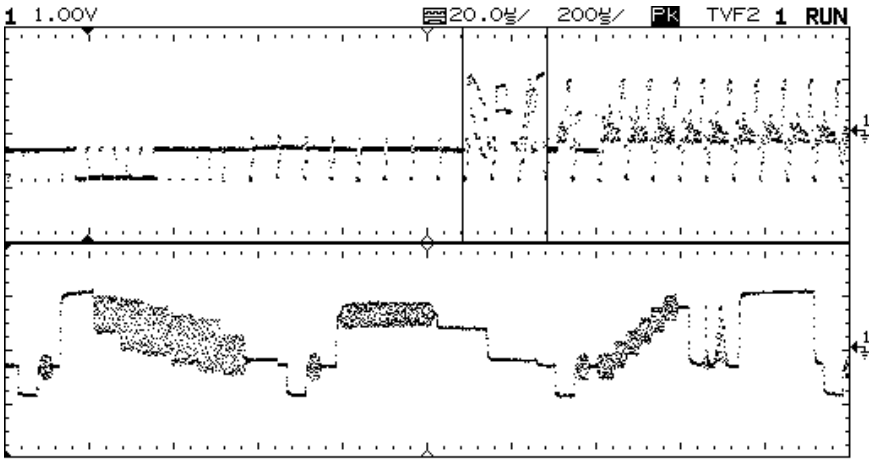
Polarity Selects either positive or negative sync pulses.
Field 1 Triggers on the field 1 portion of the video signal.
Field 2 Triggers on the field 2 portion of the video signal.
Line Triggers on all the TV line sync pulses.
HF Rej Controls a 500 kHz low pass filter in the trigger path.

5 Set the time base to 200 µs/div, then center the signal on the display with the delay knob (delay about 800 µs).

6 Press `Main/Delayed` , then press the **Delayed** softkey.

7 Set the delayed sweep to 20 µs/div, then set the expanded portion over the VITS (delay about 988.8 µs).

Figure 2–28

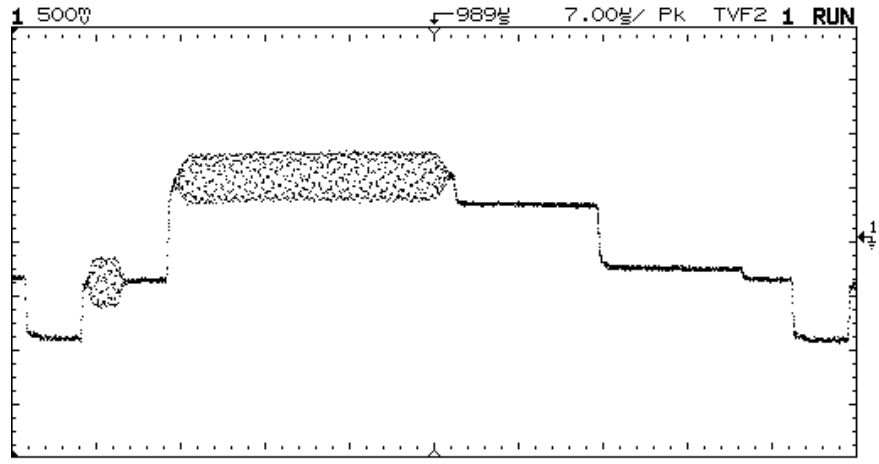


Second vertical interval windowed on the VITS

8 Press `Main/Delayed` , then press the **Main** softkey.

9 Use the horizontal vernier to change the time base to 7 µs/div, then center the signal on the display with the delay knob (delay about 989 µs).

Figure 2–29



Full screen display of the IRE

Delay in TV line units hint

HP 54600B-series oscilloscopes with system ROM versions 2.1 and greater have the ability to display delay in TV-line units. Using the TV field trigger mode activates this line-counting feature. When Field 1 or Field 2 is selected as the trigger source, delay can be set in terms of time or line number.

Both-fields triggering hint

The HP 54600B-series oscilloscopes can trigger on the vertical sync pulse in both TV fields at the same time. This allows you to view noninterlaced video signals which are common in today's computer monitors. To trigger on both sync pulses, press Field 1 and Field 2 at the same time.

TV trigger operating hints

The color burst never really changes phase, it just looks doubled triggered because its frequency is an odd multiple of one half the line frequency.

When looking at live video (usually a field), use peak detect to improve the appearance of the display.

When making cursor measurements, use Autostore since you are usually looking for pulse flatness and extremes.

When using line trigger, use minimum holdoff to display all the lines. Due to the relationship between the horizontal and vertical sync frequencies the display looks like it is untriggered, but it is very useful for TV waveform analysis and adjustment because all of the lines are displayed.

Using Option 005 Enhanced TV/Video Trigger (HP 54602B)

Using Option 005 Enhanced TV/Video Trigger

Basic TV/video triggering

This section discusses Enhanced TV/Video triggering. If you do not have Option 005 installed in your oscilloscope, refer to the last section in Chapter 2 "To analyze video waveforms" for basic TV triggering procedures.

You can use the Option 005 Enhanced TV/Video trigger with your HP 54602B oscilloscope. One of the first things you will want to do with your oscilloscope's new Option 005 Enhanced TV/Video trigger is to become acquainted with its menu choices. Therefore, we have written the exercises in this chapter to familiarize you with its basic controls.

To use the TV/Video trigger, you must be familiar with your oscilloscope. In summary, the front panel of the oscilloscope has knobs, grey keys, and white keys. The knobs are used most often and are similar to the knobs on other oscilloscopes. The grey keys bring up softkey menus on the display that allow you access to many of the oscilloscope features. The white keys are instant action keys and menus are not associated with them. The status line of the oscilloscope, located at the top of of the display, lets you quickly determine the setup of the oscilloscope.

When Option 005 is installed in the HP 54602B Oscilloscope, the **Display** menu has the extra **Grid** (graticule) choice of **TV**.

Option 005 gives you an Enhanced TV/Video Trigger for the oscilloscope, allowing highly detailed analysis of TV waveforms. This option offers:

- NTSC, PAL, PAL-M, SECAM and generic video formats
- Video autoscale
- IRE graticule and IRE cursor readout
- Full bandwidth rear panel output
- Trigger output
- Windowed FFT measurements (with Measurement/Storage module)

Now, in one easy-to-use instrument, you can measure your system's video performance as well as use your oscilloscope for troubleshooting and precision measurements. The oscilloscope's superior display gives you bright, easily viewed displays of any part of the video waveform. No longer do you need to use a viewing hood or to be constantly adjusting intensity and focus controls.

Analysis of video waveforms is simplified by the oscilloscope's ability to trigger on any selected line of the video signal. You can make additional measurements using the **All lines, Field 1, Field 2, All fields** (**Vertical** mode in **GENERIC** standard), or **Line** triggering modes. In addition, you can use the rear-panel, full-bandwidth signal and trigger outputs with a spectrum instrument or frequency counter for additional measurement power.

To select TV display grid

- Press `Display` , then press the **Grid** softkey until **TV** is selected.

To autoscale on a video signal

1. Use a cable to connect a TV signal to channel 1.
2. Press `Mode` in the TRIGGER section of the front panel, and select the **Trigger Mode TV** softkey.
3. To select a TV standard, press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Standard** softkey to select the TV standard. Your choices are **NTSC**, **PAL**, **SECAM**, and **GENERIC**. **GENERIC** is used for other TV/Video standards. If your TV standard has been previously selected, you may skip this step.
4. Press `Mode` , then press the **Video Autoscale** softkey.

Provide correct source matching

Many TV signals are produced from 75Ω sources. To provide correct matching to these sources, an HP 11094B 75Ω load is included as an accessory. For oscilloscopes that have selectable input impedance, the 1 MΩ input should be used with the 75Ω load.

The **Undo Autoscale** softkey in the `Setup` menu resets the instrument to the configuration that was present before pressing **Video Autoscale**.

To trigger on a specific line of video

TV triggering requires greater than 1/4 division of sync amplitude, either channel 1 or channel 2 as the trigger source. Turning the trigger level knob in TV trigger does not change the trigger level because the trigger level is automatically set to the sync pulse tips.

One example of triggering on a specific line of video is looking at the vertical interval test signals (VITS), which are typically in line 18. Another example is closed captioning, which is typically in line 21.

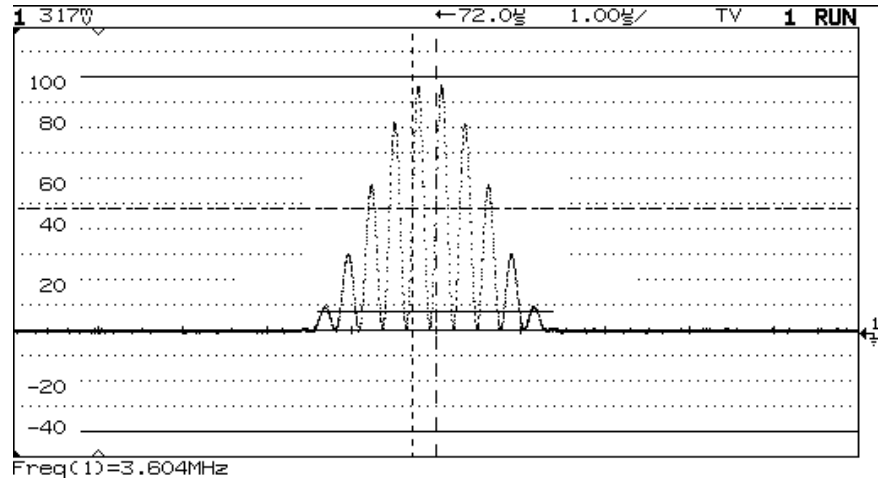
1. Select the TV display, TV as the trigger mode, and the appropriate TV standard.
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Mode** softkey until **Line** appears. Select the number of the line you want to examine by pressing the **Trigger On Line** softkey or by rotating the knob closest to the `Cursors` key.
3. Press the **Trigger On** softkey to select the TV field of the line you want to trigger on. Your choices are **Field 1**, **Field 2**, and **Alt Fld** (alternate fields).

Alternate triggering

If **Alt Fld** is selected, the oscilloscope will alternately trigger on the selected line number in Field 1 and Field 2. This is a quick way to compare the Field 1 VITS and Field 2 VITS or to check for the correct insertion of the half line at the end of Field 1.

When using **GENERIC** as the TV standard, the **Trigger On** softkey gives you the choices of **Field 1, Field 2** and **Vertical**.

Figure 3-1



Triggering on Line 71

Table 3-1 **Line Numbers per Field for Each TV Standard**

TV Standard	Field 1	Field 2	Alt Fld
NTSC	1 to 263	1 to 262	1 to 262
PAL	1 to 313	314 to 625	1 to 313
PAL-M	1 to 313	314 to 625	1 to 313
SECAM	1 to 313	314 to 625	1 to 313
GENERIC	1 to 1024	1 to 1024	1 to 1024 (Vertical)

Line Number Represents Count

In **GENERIC** mode, the line number represents the number of a count instead of a real line number. This is reflected in the label above the softkey changing from **Line** to **Cnt**. In the **Trigger On** selections, **Field 1**, **Field 2** and **Vertical** are used to indicate where the counting starts. For an interlaced TV system, the counting starts from the rising edge of the first vertical serration pulse of Field 1 and/or Field 2. For a non-interlaced TV system, the counting starts after the rising edge of the vertical sync pulse.

To trigger on all TV line sync pulses

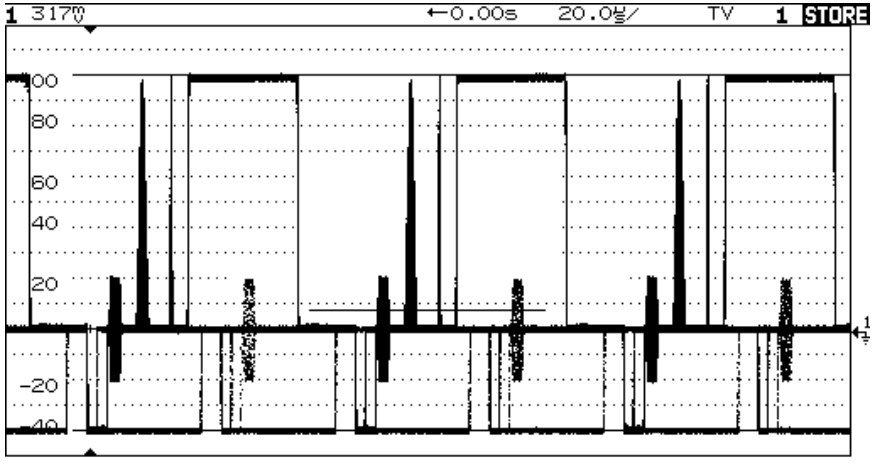
To quickly find maximum video levels, you could trigger on all TV line sync pulses. When All Lines is selected as the TV trigger mode, the oscilloscope will trigger on the first line that it finds when the acquisition starts.

1. Select the TV display, TV as the trigger mode, and the appropriate TV standard as described in the previous section, "To autoscale on a video signal."
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Mode** softkey until **All Lines** appears.

Vertical interval can be blocked

The 21 lines in the Vertical Interval can be blocked from this display if the **Vert Rej On** mode is selected. The three color sync bursts being displayed inside the white bars are on vertical interval lines. These could be removed by selection of **Vert Rej On**.

Figure 3-2



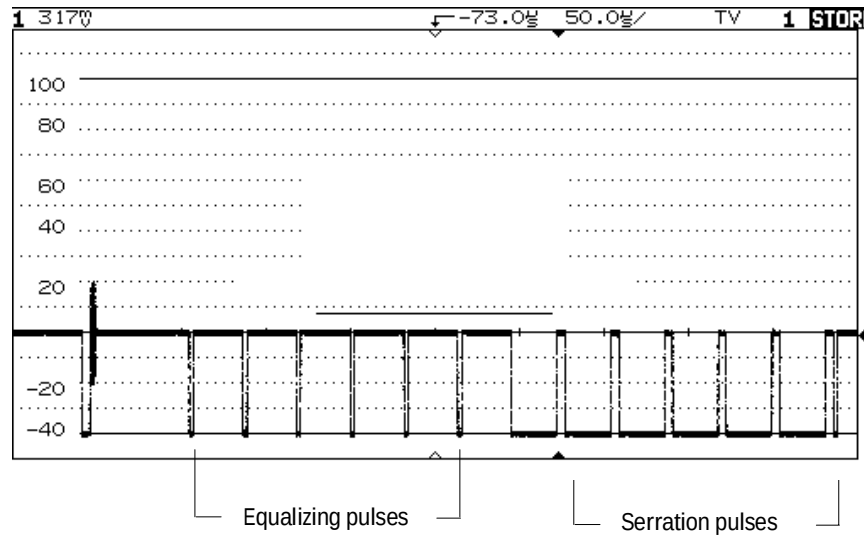
Triggering on All Lines

To trigger on a specific field of the video signal

To examine the components of a video signal, trigger on either Field 1 or Field 2. When a specific field is selected, the oscilloscope triggers on the rising edge of the first serration pulse in the vertical sync interval in the specified field (1 or 2).

1. Select the TV display, TV as the trigger mode, and the appropriate TV standard as described in the section, "To autoscale on a video signal."
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Mode** softkey until **Field 1** or **Field 2** appears.

Figure 3-3



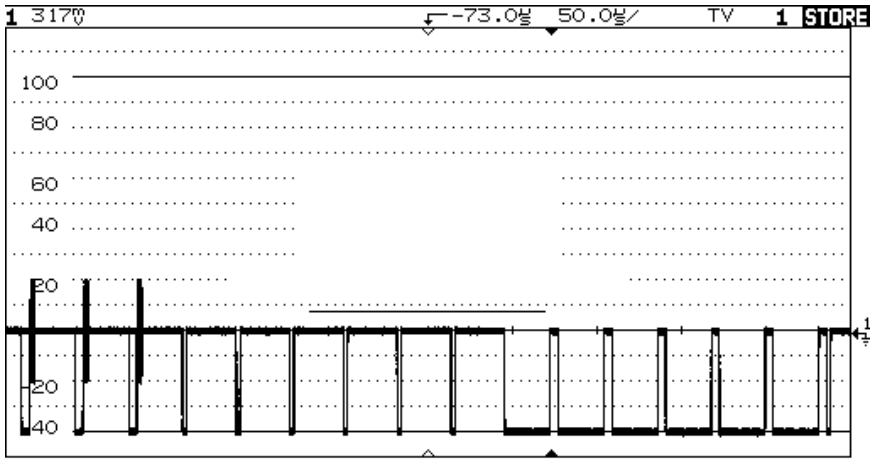
Triggering on Field 1

To trigger on all fields of the video signal

To quickly and easily view transitions between fields, or to find the amplitude differences between the fields, use the All Fields trigger. The oscilloscope will trigger on the first field it finds at the start of acquisition.

1. Select the TV display, TV as the trigger mode, and the appropriate TV standard as described in the section, "To autoscale on a video signal."
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Mode** softkey until **All Fields** appears.

Figure 3-4



Triggering on All Fields

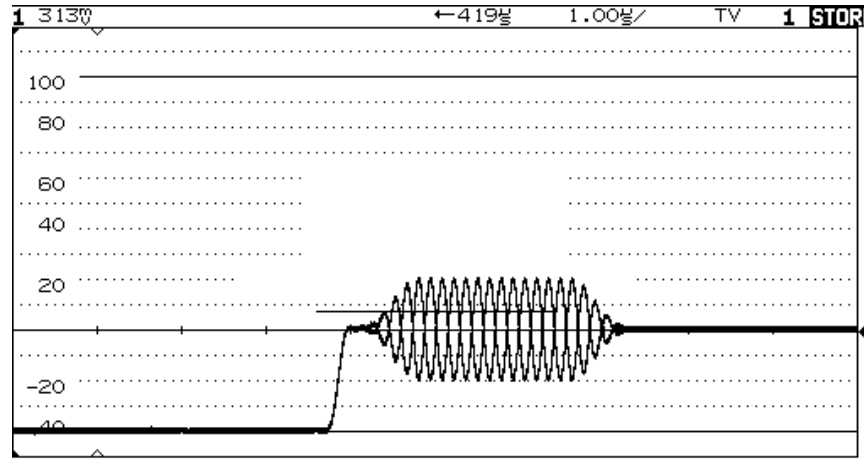
To trigger on odd or even fields

To check the envelope of your video signals, or to measure worst case distortion, trigger on the odd or even fields. When Field 1 is selected, the oscilloscope triggers on color fields 1 or 3. When Field 2 is selected, the oscilloscope triggers on color fields 2 or 4.

1. Select the TV display, TV as the trigger mode, and the appropriate TV standard as described in the section, "To autoscale on a video signal."
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **Mode** softkey until **Field 1** or **Field 2** appears.

   The trigger circuits look for the position of the start of Vertical Sync to determine the field. But this definition of field does not take into consideration the phase of the reference subcarrier. When Field 1 is selected, the trigger system will find any field where the vertical sync starts on Line 4. In the case of NTSC video, the oscilloscope will trigger on color field 1 alternating with color field 3 (see the following figure). This setup can be used to measure the envelope of the reference burst.

Figure 3-5



Triggering on Color Field 1 Alternating with Color Field 3

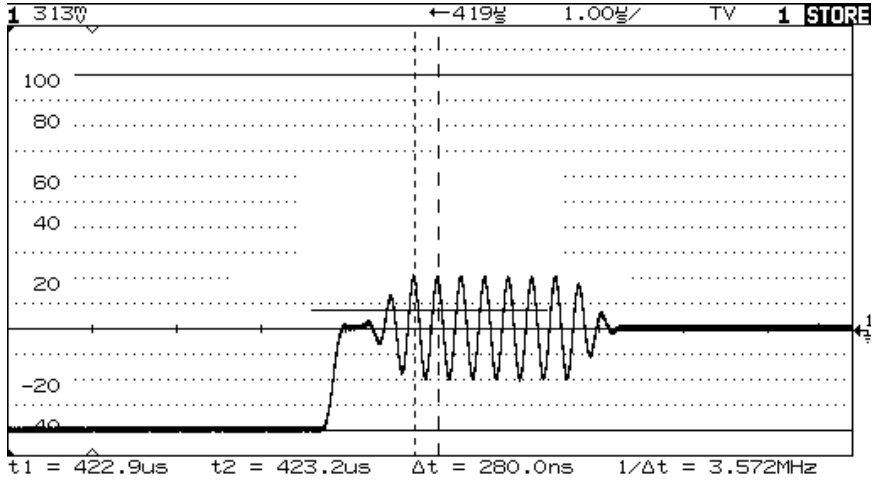
If a more detailed analysis is required, then only one color field should be selected to be the trigger. You can do this by using the oscilloscope's holdoff control. Using the holdoff settings shown in the following table, the oscilloscope will now trigger on color field 1 OR color field 3 when Field 1 is selected. This is known as odd field selection. Even fields will be selected with Field 2.

Table 3-2 **Holdoff Settings**

Video Standard	Fields/Picture	Holdoff Range
NTSC	4	33.5 ms to 50.0 ms
PAL	8	80.7 ms to 120 ms
SECAM	4	40.4 ms to 60 ms
PAL-M	8	80.4 ms to 120 ms

The holdoff can be more easily set if the sweep speed is set to 5 ms/div. Once you have established your desired holdoff time, return to the desired time base setting. The holdoff setting will remain unchanged.

Figure 3-6



Triggering on Color Field 1 using Holdoff

To make cursor measurements

The following steps guide you through the front-panel Cursors key. You can use the cursors to make custom voltage or time measurements on the signal. Examples of custom measurements include rise time measurements from reference levels other than 10-90%, frequency and width measurements from levels other than 50%, channel-to-channel delay measurements, and voltage measurements. With Option 005 in your oscilloscope, the cursors can also be calibrated in IRE units.

1. Connect a video signal to the oscilloscope and obtain a stable display.
2. Press `Display` , then press the **Grid** softkey to select **TV**.
3. Press `Mode` , then press the **Video Autoscale** softkey.
4. Press `Cursors` .

A softkey menu appears with six softkey choices. Four of the softkeys are cursor functions.

Source Selects a channel for the voltage cursor measurements. The cursor is calibrated to the Volts/div of the selected channel.

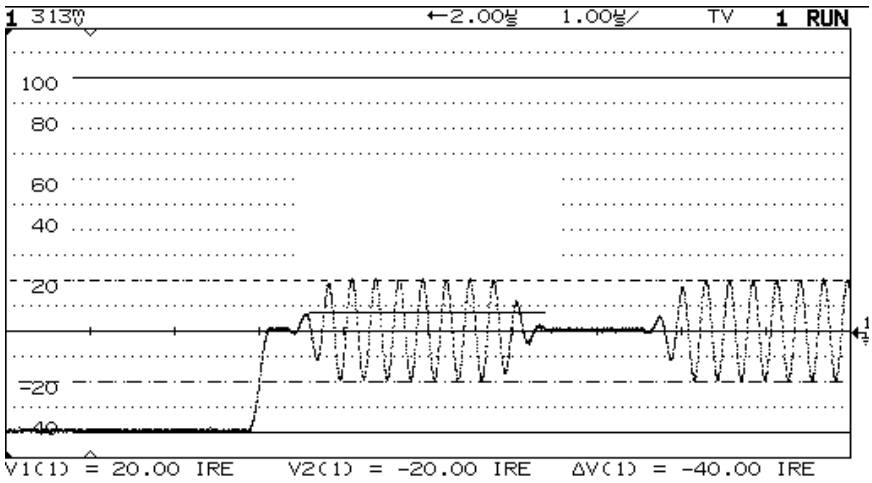
Active Cursor There are four cursor choices: **V1** and **V2** are voltage cursors, **t1** and **t2** are time cursors. Use the knob below the `Cursors` key to move the cursors. To move the cursors together, press the **V1** and **V2** softkeys simultaneously or press the **t1** and t**2** softkeys simultaneously.

Clear Cursors Erases the cursor readings and removes the cursors from the display.

TV graticule

With the TV graticule ON, the voltage cursors are calibrated in IRE units.
With the TV graticule OFF, the voltage cursors are calibrated in volts.
IRE units only make sense if the video signal is scaled properly, such as after a video autoscale.

Figure 3-7



Color Sync measured with the cursors as 40 IRE

To use delayed sweep

Delayed sweep is a magnified portion of the main sweep. You can use delayed sweep to locate and horizontally expand part of the main sweep for a more detailed (high resolution) analysis of signals, for example multi-burst frequencies. The following steps show you how to use delayed sweep. Notice that the steps are very similar to operating the delayed sweep in analog oscilloscopes.

1 Connect a signal to the oscilloscope and obtain a stable display.

2 Press `Main/Delayed` .

3 Press the **Delayed** softkey.

The screen divides in half. The top half displays the main sweep, and the bottom half displays an expanded portion of the main sweep. This expanded portion of the main sweep is called the delayed sweep. The top half also has two solid vertical lines called markers. These markers show what portion of the main sweep is expanded in the lower half. The size and position of the delayed sweep are controlled by the Time/Div and Delay knobs. The Time/Div next to the symbol is the delayed sweep sec/div. The delay value is displayed for a short time at the bottom of the display.

- To display the delay value of the delayed time base, either press `Main/Delayed` or turn the Delay knob.
- To change the main sweep Time/Div, you must turn off the delayed sweep.

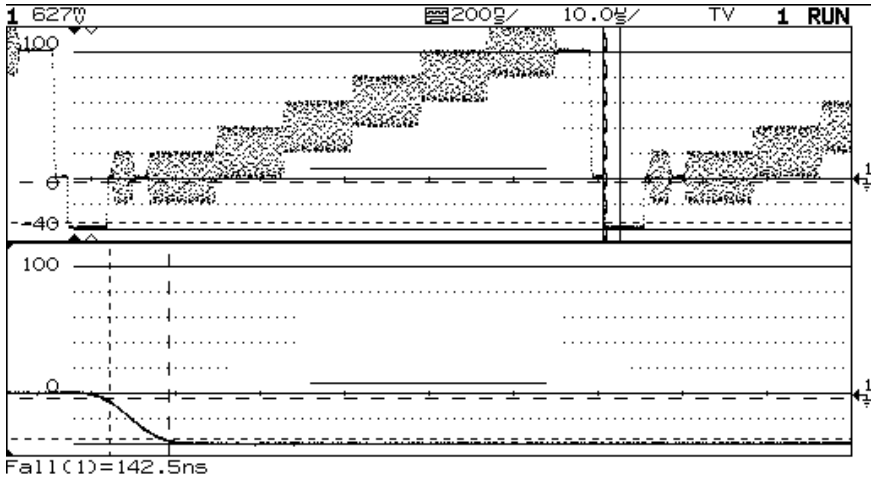
Since both the main and delayed sweeps are displayed, there are half as many vertical divisions so the vertical scaling is doubled. Notice the changes in the status line.

- To display the delay time of the delayed sweep, either press `Main/Delayed` or turn the delay knob. The delay value is displayed near the bottom of the screen.

If the TV graticule is selected, notice that it is presented in both main and delayed sweeps. For more information on delayed sweep operation, see "To use delayed sweep" in chapter 2.

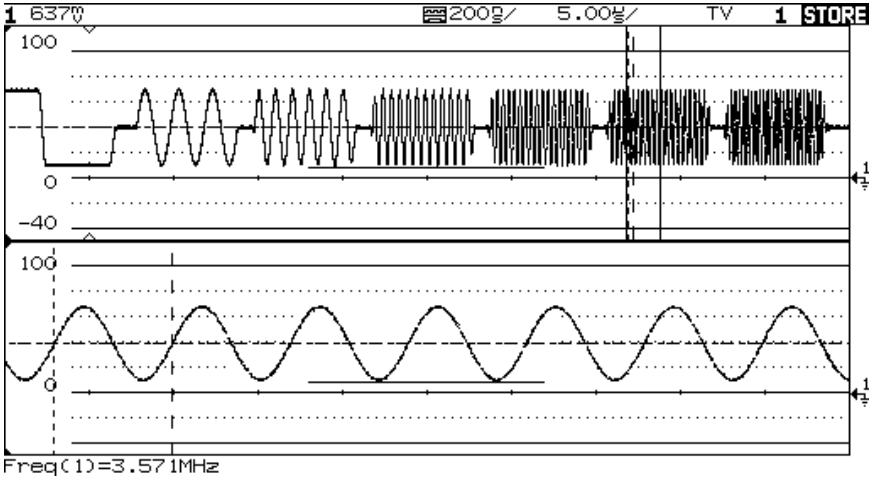
Automatic measurements are controlled by the delayed sweep shown in the following two figures.

Figure 3-8



Modulated staircase or 5-step, measuring sync pulse fall time with delayed sweep

Figure 3-9



Windowed frequency measurement in a multi-burst by use of delayed sweep

To analyze video waveforms with Option 005

The combination of the TV trigger, delayed sweep, and automatic measurements allow this oscilloscope to precisely analyze video waveforms. There is no need for external clamping to obtain a stable trigger when you are viewing unclamped video signals. This is because the TV sync separator in the oscilloscope has an internal clamp circuit in the trigger path. Because there is no clamp in the vertical path of your oscilloscope, you will be able to observe any DC level shifts in the video on the oscilloscope display. To eliminate this position shifting as the DC component of the video changes, select AC coupling.

For this exercise, we connect the oscilloscope to the video output terminals on a television. We set up the oscilloscope to view the second vertical interval with delayed sweep windowed on the vertical interval test signals (VITS). Then we make windowed measurements with the delayed sweep.

1. Connect a TV signal to channel 1, and select channel 1 as your trigger source.
2. Press `Slope/Coupling` in the TRIGGER section of the front panel, then press the **TV** softkey.
3. Select the desired TV **Standard**, such as NTSC, PAL, PAL-M or SECAM.
4. Press `Mode`, then press the **Video Autoscale** softkey.

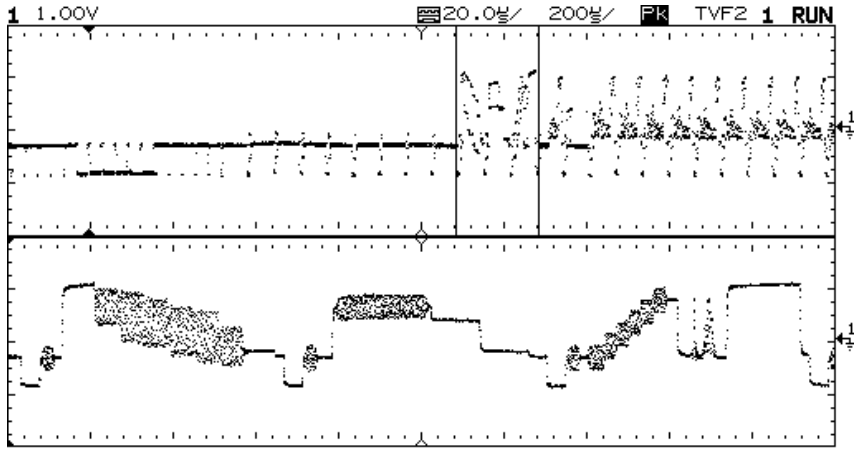
5 Set the time base to 200 µs/div, then center the signal on the display with the delay knob (delay about 800 µs).

6 Press `Main/Delayed` , then press the **Delayed** softkey.

7 Set the delayed sweep to 20 µs/div, then set the expanded portion over the VITS (delay about 988.8 µs).

Figure 3-10

This figure shows the second vertical interval test signals displayed with delayed sweep.



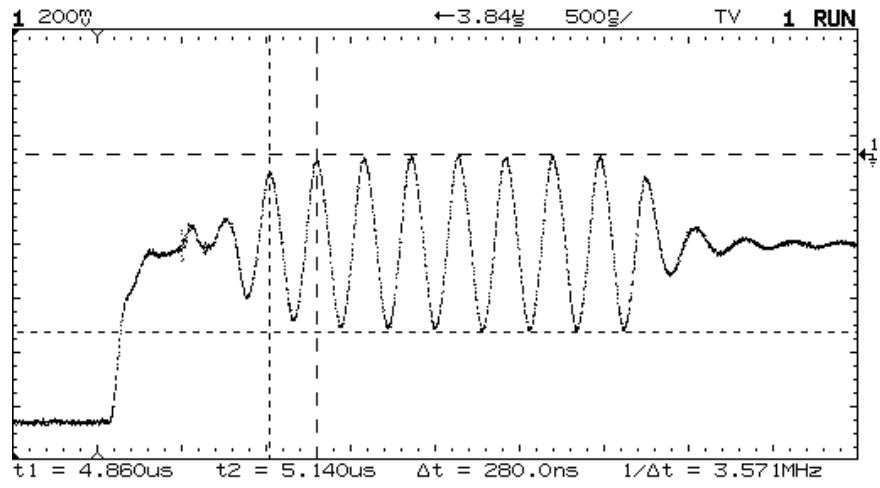
Second VITS Displayed

To window in on harmonic distortion using FFT

Sine waves that are not perfectly shaped in the time domain generate harmonics in the frequency domain. Viewing this distortion in the time domain is usually very difficult, unless the waveform is severely distorted. However, in the frequency domain, these harmonics are very apparent. Your oscilloscope, when used with the HP 54657A, HP 54658A, or HP 54659B Measurement/Storage module, have the ability to perform frequency domain analysis on a time domain waveform using the Fast Fourier Transform (FFT).

A special case of measuring the harmonic distortion in a sine wave is found in video applications. The 3.58 MHz color-subcarrier frequency embedded in an NTSC composite video signal has some amount of harmonic distortion associated with the subcarrier frequency. To measure just this signal, the scope's time/division and delay controls are used to zoom in on the color burst in the time domain.

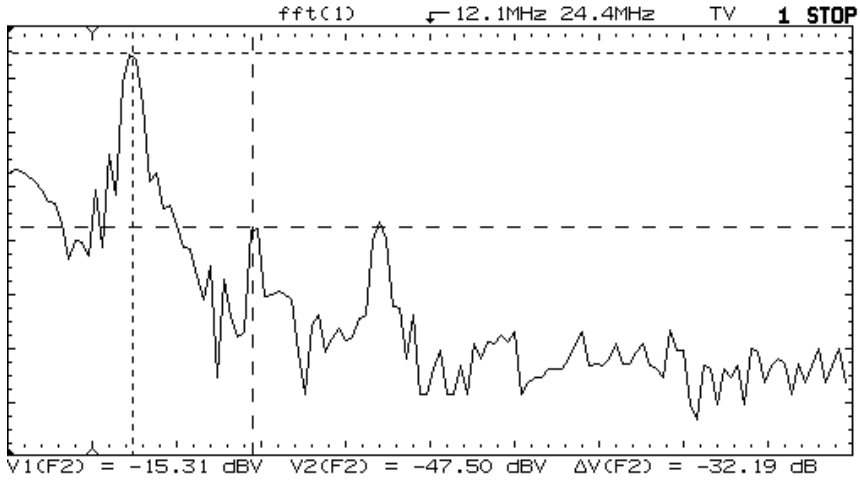
Figure 3-11



The scope controls are used to zoom in on the color burst in the time domain

The FFT function then shows the harmonic content of the subcarrier in the figure below. Had the time/division and delays controls not been used to zoom in on the desired subcarrier, the entire video signal (with many frequency components) would have appeared in the frequency domain display. These frequency components would have obscured the color subcarrier and its harmonics. This example illustrates a general technique of using the time domain controls of the scope to select specific time intervals for FFT analysis.

Figure 3-12



The FFT function shows that the harmonic content of the color busrt is more than 31 dB below the subcarrier

To connect to other instruments

The rear panel outputs provide an easy way to connect your Option 005-equipped oscilloscope to other instruments such as spectrum analyzers or frequency counters. To use a frequency counter:

1. Connect the vertical output of the oscilloscope to the counter's input.
2. Connect the frequency to be measured to channel 1.
3. Press **Autoscale**, then select the trigger source to be channel 1. Adjust the counter as required.

   The amplitude of the vertical output signal is proportional to the amplitude as displayed on the oscilloscope.

   The trigger source selection is the control that determines which channel's signal is present at the vertical output (VERT OUT) connector on the rear of the oscilloscope.

4

Verifying Oscilloscope Performance 4–5
Adjusting the Oscilloscope 4–27
Troubleshooting the Oscilloscope 4–40
Replacing Parts in the Oscilloscope 4–49

Service

Service

If the oscilloscope is under warranty, you must return it to Hewlett-Packard for all service work covered by the warranty. See "To return the oscilloscope to Hewlett-Packard," on page 4–4. If the warranty period has expired, you can still return the oscilloscope to Hewlett-Packard for all service work. Contact your nearest Hewlett-Packard Sales Office for additional details on service work.

If the warranty period has expired and you decide to service the oscilloscope yourself, the instructions in this chapter can help you keep the oscilloscope operating at optimum performance.

This chapter is divided into the following four sections:

- Verifying Oscilloscope Performance on page 4–5
- Adjusting the Oscilloscope on page 4–27
- Troubleshooting the Oscilloscope on page 4–40
- Replacing Parts in the Oscilloscope on page 4–49

Service should be performed by trained service personnel only. Some knowledge of the operating controls is helpful, and you may find it helpful to read chapter 1, "The Oscilloscope at a Glance."

Table 4-1

Recommended list of test equipment to service the oscilloscope

Equipment	Critical specifications	Recommended Model/Part	Use
Constant amplitude signal generator	100 MHz, Constant amplitude ±1% (250 MHz for HP 54602)	Tek SG503 Tek TM501	P
Digital multimeter	0.1 mV resolution, better than 0.01% accuracy	HP 34401A	P, A, T
Oscilloscope	100 MHz	HP 54600B or equivalent	T
Power supply	14 mV to 35 Vdc, 0.1 mV resolution	HP 6114A	P
Probe	10:1 division ratio	HP 10432A	T
Pulse generator	Rise time < 875 ps	PSPL 1107B TD and PSPL 1110B Driver	A
Pulse generator	10 kHz, 500 mV p-p, rise time <5 ns	HP 8112A	A
Time marker generator	Stability 5 ppm after 1/2 hour	TG 501A and TM 503A	P
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C	P, A
Power splitter	Outputs differ <0.15 dB	HP 11667B	P
Shorting cap	BNC	HP 1250-0774	P
Adapter	SMA (f) to BNC (m)	HP 1250-1787	A
Adapter	BNC (f-f)	HP 1250-0080	A
Adapter	BNC tee (m) (f) (f)	HP 1250-0781	A
Adapter	N (m) to BNC (f), Qty 3	HP 1250-0780	P
Adapter	BNC (f) to dual banana (m)	HP 1251-2277	P
Cable	BNC, Qty 3	HP 10503A	P, A
Cable	BNC, 9 inches, Qty 2	HP 10502A	A
Additional equipment needed if you perform the alternate bandwidth test when verifying oscilloscope performance.			
Signal generator	1 to 100 MHz at 200 mV (250 MHz for HP 54602B)	HP 8656B opt 001	P
Power meter and Power Sensor	1 to 100 MHz ±3% accuracy (250 MHz for HP 54602B)	HP 436A and HP 8482A	P
Cable	Type N (m) 24 inch	HP 11500B	P
Adapter	Type N (m) to BNC (m)	HP 1251-0082	P

To return the oscilloscope to Hewlett-Packard

Before shipping the oscilloscope to Hewlett-Packard, contact your nearest Hewlett-Packard Sales Office for additional details.

1. **Write the following information on a tag and attach it to the oscilloscope.**
   - Name and address of owner
   - Model number
   - Serial number
   - Description of service required or failure indications
2. **Remove all accessories from the oscilloscope.**

   The accessories include the power cord, probes, cables, and any modules attached to the rear of the oscilloscope. Do not ship accessories back to Hewlett-Packard unless they are associated with the failure symptoms.
3. **Protect the control panel with cardboard.**
4. **Pack the oscilloscope in styrofoam or other shock-absorbing material and place it in a strong shipping container.**

   You can use either the original shipping containers, or order materials from an HP Sales Office. Otherwise, pack the oscilloscope in 3 to 4 inches of shock-absorbing material to prevent movement inside the shipping container.
5. **Seal the shipping container securely.**
6. **Mark the shipping container as FRAGILE.**

Verifying Oscilloscope Performance

This section shows you how to verify the electrical performance of the oscilloscope, using the performance characteristics in chapter 5 as the standard. The characteristics checked are dc calibrator, voltage measurement accuracy, bandwidth, horizontal accuracy, and trigger sensitivity.

You should verify the performance of the oscilloscope when you first receive it, and every 12 months or after 2,000 hours of operation. Also, make sure you allow the oscilloscope to operate for at least 30 minutes before you begin the following procedures.

Perform self-calibration first

For the oscilloscope to meet all of the verifications tests in the ambient temperature where it will be used, the self-calibration tests described on page 4–31 should first be performed. Allow the unit to operate for at least 30 minutes before performing the self-calibration.

Each procedure lists the recommended equipment for the test. You can use any equipment that meets the critical specifications. However, the procedures are based on the recommended model or part number.

Starting on page 4–23 is a series of test records (one for each model of osciiloscope) for recording the test results of each procedure. Use the test results to gauge the performance of the oscilloscope over time.

To check the output of the DC CALIBRATOR

In this test you measure the output of the DC CALIBRATOR with a multimeter. The DC CALIBRATOR is used for self-calibration of the oscilloscope. The accuracy is not specified, but it must be within the test limits to provide for accurate self-calibration.

Test limits 5.000 V ±10 mV and 0.000 V ± 500 µV.

Table 4-2 Equipment Required

Equipment	Critical specifications	Recommended Model/Part
Digital Multimeter	0.1 mV resolution, better than 0.01% accuracy	HP 34401A
Cable	BNC	HP 10503A

1. Connect a multimeter to the rear panel DC CALIBRATOR connector.
2. Press `Print/Utility` .
3. Press the **Self Test** softkey, then press the **DAC** softkey.

   The multimeter should measure 0.00 V dc ± 500 µV. If the result is not within the test limits, see "Troubleshooting the oscilloscope," on page 4–40.
4. Press any key to continue the test.

   The multimeter should read 5.000 V ±10 mV. If the result is not within the test limits, see "Troubleshooting the oscilloscope," on page 4–40.

To verify voltage measurement accuracy

In this test you verify the voltage measurement accuracy by measuring the output of a power supply using dual cursors on the oscilloscope, and comparing the results with a multimeter.

Test limits ±1.9% of full scale (HP 54600B, HP 54601B, HP 54602B)
±2.4% of full scale (HP 54603B)

Table 4-3 Equipment Required

Equipment	Critical specifications	Recommended Model/Part
Power supply	14 mV to 35 Vdc, 0.1 mV resolution	HP 6114A
Digital multimeter	Better than 0.1% accuracy	HP 34401A
Cable	BNC, Qty 2	HP 10503A
Shorting cap	BNC	HP 1250-0774
Adapter	BNC (f) to banana (m)	HP 1251-2277
Adapter	BNC tee (m) (f) (f)	HP 1250-0781

1 Set up the oscilloscope.
   a Press **Setup** , then press the **Default Setup** softkey.
   b Press **Voltage** , then press the **V avg** softkey.
   c Set the Volts/Div to the first line of table 4-4.
   d Adjust the channel 1 Position knob to place the baseline near (but not at) the bottom of the display.
2 Press **Cursors** , then press the **V1** softkey.
3 Using the cursors knob, set the V1 cursor on the baseline.

   If you are in an electrically noisy environment, it can help to place a shorting cap on the input BNC connector when positioning V1.
4 Connect the power supply to the oscilloscope and to the multimeter, using the BNC tee and cables.
5 Set the power supply output to the first line in table 4-4.

6 Press the **V2** softkey, then position the V2 cursor to the baseline.

The ΔV value at the bottom of the display should be within the test limits of table 4-4. If a result is not within the test limits, see "Troubleshooting the Oscilloscope," on page 4–40.

7 Continue checking the voltage measurement accuracy with the remaining lines in table 4-4.

Table 4-4
Voltage Measurement Accuracy

Volts/Div setting	Power supply setting	Test limits		
		HP 54600B, HP 54601B	HP 54602	HP 54603B
5 V/Div	35 V	34.24 V to 35.76 V	34.24 V to 35.76 V	34.04 V to 35.96 V
2 V/Div	14 V	13.70 V to 14.30 V	13.70 V to 14.30 V	13.62 V to 14.38 V
1 V/Div	7 V	6.848 V to 7.152 V	6.848 V to 7.152 V	6.808 V to 7.192 V
0.5 V/Div	3.5 V	3.424 V to 3.576 V	3.424 V to 3.576 V	3.404 V to 3.596 V
0.2 V/Div	1.4 V	1.370 V to 1.430 V	1.370 V to 1.430 V	1.362 V to 1.438 V
0.1 V/Div	700 mV	684.8 mV to 715.2 mV	684.8 mV to 715.2 mV	680.8 mV to 719.2 mV
50 mV/Div	350 mV	342.4 mV to 357.6 mV	342.4 mV to 357.6 mV	340.4 mV to 359.6 mV
20 mV/Div	140 mV	137.0 mV to 143.0 mV	137.0 mV to 143.0 mV	136.2 mV to 143.8 mV
10 mV/Div	70 mV	68.48 mV to 71.52 mV	68.48 mV to 71.52 mV	68.08 mV to 71.92 mV
5 mV/Div*	35 mV	34.48 mV to 36.52 mV	34.24 mV to 35.76 mV	33.08 mV to 36.92 mV
2 mV/Div*	14 mV	12.48 mV to 15.52 mV	13.70 mV to 14.30 mV	12.08 mV to 15.92 mV
1 mV/Div**	7 mV	—	6.696 mV to 7.304 mV	—

* Full scale is defined as 80 mV for the 5 mV/div and 2 mV/div ranges on HP 54600B, HP 54601B, HP 54603B.
** 1 mV/div range only on HP 54602B. Full scale is defined as 16 mV .

8 Disconnect the power supply from the oscilloscope, then repeat steps 1 to 7 for channel 2 (channels 2 to 4 on the HP 54601B and HP 54602B). On the HP 54601B and HP 54602B, channels 3 and 4, check the 0.5 V/div and 0.1 V/div range only.

To verify bandwidth

In this test you verify the bandwidth of the oscilloscope by using a constant amplitude signal generator. The frequency of the signal generator is set to 250 kHz to establish a reference level. Then, the frequency is changed to the upper bandwidth limit and the level is checked to see if it is 3 dB from the reference level.

The following procedure is a simple method to check bandwidth. However, there is a possibility of measurement uncertainty with a constant amplitude signal generator. If you need a more exact procedure for checking bandwidth see, "To verify the bandwidth (alternate method)" on page 4–12.

Test limits

HP 54600B and HP 54601B, all channels (–3 dB)
dc to 100 MHz
ac coupled 10 Hz to 100 MHz.

HP 54602B
Channels 1 & 2 (–3 dB)
10 mV/div to 5 V/div
dc to 150 MHz
1 mV/div to 5 mV/div
dc to 100 MHz
ac coupled 10 Hz to upper limit of vertical range
Channels 3 & 4 (–3 dB)
dc to 250 MHz.

HP 54603B, all channels (–3 dB)
dc to 60 MHz
ac coupled 10 Hz to 60 MHz.

Table 4-5 Equipment Required

Equipment	Critical specifications	Recommended Model/Part
Constant amplitude signal generator	100 MHz, Constant amplitude ±1% (250 MHz for HP 54602B)	Tek SG503/Tek TM501
Cable	BNC	HP 10503A
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Using the 50-Ω feedthrough and the BNC cable, connect the signal generator to channel 1 of the oscilloscope.
2 Set the frequency of the signal generator to 250 kHz and the amplitude to about 800 mV.
3 Press `Autoscale` .
4 Adjust the output of the signal generator for exactly 8 divisions of vertical deflection.
5 Change the frequency of the signal generator to the value shown below for your instrument.

Table 4-6 **Signal Generator Frequency Setting**

Selected Channel	HP 54600B	HP 54601B	HP 54602B *	HP 54603B
Channel 1	100 MHz	100 MHz	150 MHz	60 MHz
Channel 2	100 MHz	100 MHz	150 MHz	60 MHz
Channel 3	—	100 MHz	250 MHz	—
Channel 4	—	100 MHz	250 MHz	—

*1mv/div to 5 mv/div dc = 100 MHz.

6 Change the sweep speed of the oscilloscope to 5 ns/div and observe the display.
The vertical amplitude of the signal on the display should be equal to or greater than 5.66 divisions (–3 dB point). If the result is not ≤–3 dB, see "Troubleshooting the Oscilloscope," on page 4–40.
7 Repeat steps 1 through 6 for channel 2 (channels 2 to 4 on the HP 54601B and HP 54602B).

To verify bandwidth (alternate method)

In this test you verify the bandwidth of the oscilloscope by using a power meter and power sensor to set the output of a signal generator at 1 MHz and the upper bandwidth limit. You use the peak-to-peak voltage at 1 MHz and the upper bandwidth limit to calculate the bandwidth response of the oscilloscope.

Test limits

HP 54600B and HP 54601B, all channels (–3 dB)
dc to 100 MHz
ac coupled 10 Hz to 100 MHz.

HP 54602B
Channels 1 & 2 (–3 dB) *
dc to 150 MHz
ac coupled 10 Hz to 150 MHz.
Channels 3 & 4 (–3 dB)
dc to 250 MHz.

HP 54603B, all channels (–3 dB)
dc to 60 MHz
ac coupled 10 Hz to 60 MHz.

Table 4-7 Equipment Required

Equipment	Critical specifications	Recommended Model/Part
Signal generator	1 to 100 MHz at 200 mV (250 MHz for HP 54602B)	HP 8656B opt 001
Power meter and Power Sensor	1 to 100 MHz ±3% accuracy (250 MHz for HP 54602B)	HP 436A and HP 8482A
Power splitter	Outputs differ by <0.15 dB	HP 11667B
Cable	Type N (m), 24 inch	HP 11500B
Adapter	Type N (m) to BNC (m)	HP 1251-0082
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

*1mv/div to 5 mv/div dc = 100 MHz.

1 Connect the equipment.
   a Connect the signal generator to the input of the power splitter.
   b Connect the power sensor to one output of the power splitter, and connect channel 1 of the oscilloscope to the other power splitter output (put the 50 Ω feedthrough at the input of the oscilloscope).
2 Set up the oscilloscope.
   a Press `Setup` , then press the **Default Setup** softkey.
   b Set the time base to 500 ns/div.
   c Set channel 1 to 100 mV/div.
   d Press `Display` , then press the **Average** softkey.
   e Toggle the **# Average** softkey to select **8** averages.
3 Set the signal generator for 1 MHz at about 5.6 dBm.

   Notice that the signal on the display is about 5 cycles and six divisions of amplitude.

4 Press Voltage , then press the **Vp-p** softkey.

Wait a few seconds for the measurement to settle (averaging is complete), then note the Vp-p reading from the bottom of the display.
Vp-p = _____ mV.

5 Set the calibration factor percent of the power meter to the 1 MHz value from the calibration chart on the probe, then press dB (REF) on the power meter to set a 0 dB reference.

6 Change the frequency of the signal generator to the value shown below for your instrument.

Table 4-8 **Signal Generator Frequency Setting**

Selected Channel	HP 54600B	HP 54601B	HP 54602B *	HP 54603B
Channel 1	100 MHz	100 MHz	150 MHz	60 MHz
Channel 2	100 MHz	100 MHz	150 MHz	60 MHz
Channel 3	—	100 MHz	250 MHz	—
Channel 4	—	100 MHz	250 MHz	—

*1mv/div to 5 mv/div = 100 MHz.

7 Set the calibration factor of the power meter to 100 MHz percent value from the chart on the probe.

Adjust the amplitude of the signal generator for a power reading as close as possible to 0.0 dB (REL). Power meter reading = _____ dB.

8 Change the time base to 5 ns/div.

Wait a few seconds for the measurement to settle (averaging is complete), then note the Vp-p reading from the bottom of the display.
Vp-p = _____ mV.

9 Calculate the response using the following formula.

$$20 \log_{10} \left(\frac{step\,8\ result}{step\,4\ result} \right)$$

10 Correct the result from step 9 with any difference in the power meter reading from step 7. Make sure you observe all number signs.

For example

Result from step 9 = –2.3 dB
Power meter reading from step 7 = –0.2 dB (REL)
True response = (–2.3) – (–0.2) = –2.1 dB
The true response should be ≤±3 dB.

If the result is not ≤±3 dB, see "Troubleshooting the Oscilloscope," on page 4–40.

11 Repeat steps 1 to 10 for channel 2 (channels 2 to 4 on the HP 54601B and HP 54602B).

When you measure the bandwidth on channels 3 and 4, use the 0.1 V/Div range.

To verify horizontal Δt and 1/Δt accuracy

In this test you verify the horizontal Δt and 1/Δt accuracy by measuring the output of a time mark generator with the oscilloscope.

Test limits ±0.01% ±0.2% of full scale ±200 ps.

Table 4-9 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Time marker generator	Stability 5 ppm after 1/2 hour	TG 501A and TM 503A
Cable	BNC	HP 10503A
Termination	50 Ω, BNC connectors (m) (f)	HP 10100C

1 Connect the time mark generator to channel 1 using the feedthrough at the oscilloscope input. Then, set the time mark generator for 0.1 ms markers.

2 Setup the oscilloscope.

- **a** Press `Setup` , then press the **Default Setup** softkey.
- **b** Press `Diplay` , then press the **Vectors Off** softkey.
- **c** Press `Autoscale` .
- **d** Set the time base to 20 µs/div.
- **e** Adjust the trigger level to obtain a stable display.

3 Press Time , then press the **Freq** and **Period** softkeys.

You should measure the following:
Frequency 10 kHz, test limits are 9.959 kHz to 10.04 kHz.
Period 100 µs, test limits are 99.59 µs to 100.4 µs.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page4–40.

4 Change the time mark generator to 1 µs, and change the time base to 200 ns/div. Adjust the trigger level to obtain a stable display.

5 Press Time , then press the **Freq** and **Period** softkeys.

You should measure the following:
Frequency 1 MHz, test limits are 995.7 kHz to 1.004 MHz.
Period 1 µs, test limits are 995.7 ns to 1.004 µs.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 4–40.

HP 54600B, HP 54601B, HP 54602B only

6 Change the time mark generator to 10 ns, and change the time base to 5 ns/div. Adjust the trigger level to obtain a stable display.

7 Press Time , then press the **Freq** and **Period** softkeys.

You should measure the following:
Frequency 100 MHz, test limits are 97.08 MHz to 103.1 MHz.
Period 10 ns, test limits are 9.699 ns to 10.30 ns.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 4–40.

HP 54603B only

8 Change the time mark generator to 20 ns, and change the time base to 5 ns/div. Adjust the trigger level to obtain a stable display.

9 Press Time , then press the **Freq** and **Period** softkeys.

You should measure the following:
Frequency 50 MHz, test limits are 49.25 MHz to 50.77 MHz.
Period 20 ns, test limits are 19.70 ns to 20.30 ns.

If the measurements are not within the test limits, see "Troubleshooting the Oscilloscope," on page 4–40.

To verify trigger sensitivity

In this test you verify the trigger sensitivity by applying 25 MHz to the oscilloscope. The amplitude of the signal is decreased to the specified levels, then you check to see if the oscilloscope is still triggered. You then repeat the process at the upper bandwidth limit.

Test limits

Internal trigger

HP 54600B and HP 54601B, all channels
- dc to 25 MHz, 0.35 div or 3.5 mV p-p
- dc to 100 MHz, 1 div or 10 mV p-p

HP 54602B
- Channels 1 & 2
  - >5 mV/div
    - dc to 25 MHz, 0.35 div or 3.5 mV p-p
    - dc to 150 MHz, 1 div or 10 mV p-p
  - 1 mV to 5 mV/div
    - dc to 25 MHz, 1 div or 2 mV
    - dc to 100 MHz, 1.5 div or 3 mV
- Channels 3 & 4
  - dc to 25 MHz, 0.35 div or 3.5 mV p-p
  - dc to 250 MHz, 1 div or 100 mV p-p

HP 54603B, all channels
- dc to 25 MHz, 0.35 div or 3.5 mV p-p
- dc to 60 MHz, 1 div or 10 mV p-p

External trigger

HP 54600B and HP 54603B only
- dc to 25 MHz, 50 mV p-p
- dc to 100 MHz, 100 mV p-p (HP 54600B)
- dc to 60 MHz, 100 mV p-p (HP 54603B)

Table 4-10 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Signal generator	sine waves: 25 MHz and 100 MHz–HP 54600B/HP 54601B 25 MHz and 250 MHz–HP 54602B 25 MHz and 60 MHz–HP 54603B	Tek SG 503/Tek TM 501
Power splitter (HP 54600B/03B only)	Outputs differ <0.15 dB	HP 11667B
Cable	BNC, Qty 3	HP 10503A
Adapter	N (m) to BNC (f), Qty 3	HP 1250-0780
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

Internal Trig Sensitivity

1 Press `Setup` , then press the **Default Setup** softkey.

2 Connect the signal generator to channel 1.

3 Verify the trigger sensitivity at 25 MHz and 0.35 divisions.

a Set the signal generator to 25 MHz and about 50 mV.

b Press `Autoscale` .

c Decrease the output of the signal generator until there is 0.35 vertical divisions of the signal displayed.

The trigger should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 4–40.

4 Verify the trigger sensitivity at 1 division for the frequencies shown below.

a Change the output of the signal generator to the frequency shown below for your instrument and set amplitude to about 100 mV.

Table 4-11 **Signal Generator Frequency Setting**

Selected Channel	HP 54600B	HP 54601B	HP 54602B *	HP 54600B
Channel 1	100 MHz	100 MHz	150 MHz	60 MHz
Channel 2	100 MHz	100 MHz	150 MHz	60 MHz
Channel 3	—	100 MHz	250 MHz	—
Channel 4	—	100 MHz	250 MHz	—

*1mv/div to 5 mv/div = 100 MHz.

b Press `Autoscale` .

c Decrease the output of the signal generator until there is 1 vertical division of the signal displayed.

The trigger should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 4–40.

5 Repeat steps 1 through 4 for channel 2 on the HP 54600B and HP 54603B (channels 2 to 4 on the HP 54601B and HP 54602B).

External Trig Sensitivity

6 Verify the external trigger sensitivity at 100 MHz (60 MHz for HP 54603B) and 100 mV p-p (HP 54600B and HP 54603B only).

a Press `Source` , then press the **Ext** softkey.

b Use the power splitter to connect the signal generator to the channel 1 input and to the external trigger input.

c Change the output of the signal generator to 100 MHz and 200 mV p-p.

The power splitter divides the 200 mV so that 100 mV is applied to each of the oscilloscope inputs.

The oscilloscope triggering should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 4–40.

7 Verify the external trigger sensitivity at 25 MHz and 50 mV p-p (HP 54600B and HP 54603B only).

a Change the output of the signal generator to 25 MHz at about 100 mV.

b Press `Autoscale` .

The oscilloscope triggering should be stable. If the triggering is not stable, try adjusting the trigger level. If adjusting the trigger level makes the triggering stable, the test still passes. If adjusting the trigger does not help, see "Troubleshooting the Oscilloscope," on page 4–40.

To verify Vertical Output on Option 005

This section applies only to Option 005 Enhanced TV/Video Trigger if installed on the HP 54602B.

In this test we will use the oscilloscope's channel 2 to measure the amplitude of the Vertical Output (VERT OUT connector on rear panel) signal.

Test limits: ~90 mVp-p into 50Ω with a full screen input.

Table 4-8 Equipment Required

Equipment	Critical specifications	Recommended Model/Part
Signal generator	1 to 500 MHz at 200 mV	HP 8656B opt 001
Cable	BNC, 48 inch	HP 10503A
Cable	Type N (m), 24 inch	HP 11500B
Adapter	Type N (m) to BNC (f)	HP 1251-0780

1. Connect the signal generator to oscilloscope channel 1 input.
2. Set the signal generator to equal the full bandwidth of your oscilloscope, and set the output level to 0 dBm.
3. Connect the signal generator to oscilloscope channel 1. Set channel 1 **Input** to **50Ω** to correctly terminate the signal generator.
4. Press `Autoscale` .
5. Adjust the oscilloscope controls and signal generator to obtain an 8-division high display.
6. Connect oscilloscope rear-panel VERT OUT to oscilloscope channel 2. Set channel 2 **Input** to **50Ω** mode.
7. Measure the peak-to-peak amplitude of channel 2. It should be greater than or equal to 63.6 mVp-p.

   Because the measurement is being made at the full bandwidth of the oscilloscope's channel, the peak-to-peak measurement is corrected for the oscilloscope's high frequency roll off.

HEWLETT PACKARD

HP 54600B
Performance Test Record

Serial No. _____
Test Interval _____
Recommended Next Testing _____

Date _____
Test by _____
Work Order No. _____
Temperature _____

Output of dc calibrator	**Limits**	**Result**
	4.990 V to 5.010 V	_____

Voltage measurement accuracy

Range	**Reading**	**Test Limits**	**Channel 1**	**Channel 2**
5 V/Div	35 V	34.24 V to 35.76 V	_____	_____
2 V/Div	14 V	13.70 V to 14.30 V	_____	_____
1 V/Div	7 V	6.848 V to 7.152 V	_____	_____
500 mV/Div	3.5 V	3.424 V to 3.576 V	_____	_____
200 mV/Div	1.4 V	1.370 V to 1.430 V	_____	_____
100 mV/Div	700 mV	684.8 mV to 715.2 mV	_____	_____
50 mV/Div	350 mV	342.4 mV to 357.6 mV	_____	_____
20 mV/Div	140 mV	137.0 mV to 143.0 mV	_____	_____
10 mV/Div	70 mV	68.48 mV to 71.52 mV	_____	_____
5 mV/Div	35 mV	34.48 mV to 35.52 mV	_____	_____
2 mV/Div	14 mV	12.48 mV to 15.52 mV	_____	_____

Bandwidth	**Test Limits**	**Channel 1**	**Channel 2**
	≤±3 dB	_____	_____

Horizontal Δt and 1/Δt accuracy

	Reading	**Test Limits**	**Results**
Frequency	10 kHz	9.959 kHz to 10.04 kHz	_____
Period	100 µs	99.59 µs to 100.4 µs	_____
Frequency	1 MHz	995.7 kHz to 1.004 MHz	_____
Period	1 µs	995.7 ns to 1.004 µs	_____
Frequency	100 MHz	97.08 MHz to 103.1 MHz	_____
Period	10 ns	9.699 ns to 10.30 ns	_____

Trigger sensitivity	**Test Limits**	**Channel 1**	**Channel 2**
Internal trigger	25 MHz at 0.35 divisions	_____	_____
	100 MHz at 1 division	_____	_____
		External	
External trigger	100 MHz at 100 mV p-p	_____	
	25 MHz at 50 mV p-p	_____	

HEWLETT PACKARD

HP 54601B
Performance Test Record

Date _____
Serial No. _____ Test by _____
Test Interval _____ Work Order No. _____
Recommended Next Testing _____ Temperature _____

Output of dc calibrator	Limits	Result
	4.990 V to 5.010 V	_____

Voltage measurement accuracy

Range	Reading	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
5 V/Div	35 V	34.24 V to 35.76 V	_____	_____	_____	_____
2 V/Div	14 V	13.70 V to 14.30 V	_____	_____	_____	_____
1 V/Div	7 V	6.848 V to 7.152 V	_____	_____	_____	_____
500 mV/Div	3.5 V	3.424 V to 3.576 V	_____	_____	_____	_____
200 mV/Div	1.4 V	1.370 V to 1.430 V	_____	_____	_____	_____
100 mV/Div	700 mV	684.8 mV to 715.2 mV	_____	_____	_____	_____
50 mV/Div	350 mV	342.4 mV to 357.6 mV	_____	_____	_____	_____
20 mV/Div	140 mV	137.0 mV to 143.0 mV	_____	_____	_____	_____
10 mV/Div	70 mV	68.48 mV to 71.52 mV	_____	_____	_____	_____
5 mV/Div	35 mV	34.48 mV to 35.52 mV	_____	_____	_____	_____
2 mV/Div	14 mV	12.48 mV to 15.52 mV	_____	_____	_____	_____

Bandwidth	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
	≤±3 dB	_____	_____	_____	_____

Horizontal Δt and 1/Δt accuracy

	Reading	Test Limits	Results
Frequency	10 kHz	9.959 kHz to 10.04 kHz	_____
Period	100 µs	99.59 µs to 100.4 µs	_____
Frequency	1 MHz	995.7 kHz to 1.004 MHz	_____
Period	1 µs	995.7 ns to 1.004 µs	_____
Frequency	100 MHz	97.08 MHz to 103.1 MHz	_____
Period	10 ns	9.699 ns to 10.30 ns	_____

Trigger sensitivity	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
Internal trigger	25 MHz at 0.35 divisions	_____	_____	_____	_____
	100 MHz at 1 division	_____	_____	_____	_____

HEWLETT PACKARD

HP 54602B
Performance Test Record

Serial No. _____
Test Interval _____
Recommended Next Testing _____

Date _____
Test by _____
Work Order No. _____
Temperature _____

Output of dc calibrator	Limits	Result
	4.990 V to 5.010 V	_____

Voltage measurement accuracy

Range	Reading	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
5 V/Div	35 V	34.24 V to 35.76 V	_____	_____	_____	_____
2 V/Div	14 V	13.70 V to 14.30 V	_____	_____	_____	_____
1 V/Div	7 V	6.848 V to 7.152 V	_____	_____	_____	_____
500 mV/Div	3.5 V	3.424 V to 3.576 V	_____	_____	_____	_____
200 mV/Div	1.4 V	1.370 V to 1.430 V	_____	_____	_____	_____
100 mV/Div	700 mV	684.8 mV to 715.2 mV	_____	_____	_____	_____
50 mV/Div	350 mV	342.4 mV to 357.6 mV	_____	_____	_____	_____
20 mV/Div	140 mV	137.0 mV to 143.0 mV	_____	_____	_____	_____
10 mV/Div	70 mV	68.48 mV to 71.52 mV	_____	_____	_____	_____
5 mV/Div	35 mV	34.24 mV to 35.76 mV	_____	_____	_____	_____
2 mV/Div	14 mV	13.70 mV to 14.30 mV	_____	_____	_____	_____
1 mV/Div	7 mV	6.696 mV to 7.304 mV	_____	_____	_____	_____

Bandwidth	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
	≤±3 dB	_____	_____	_____	_____

Horizontal Δt and 1/Δt accuracy

	Reading	Test Limits	Results
Frequency	10 kHz	9.959 kHz to 10.04 kHz	_____
Period	100 µs	99.59 µs to 100.4 µs	_____
Frequency	1 MHz	995.7 kHz to 1.004 MHz	_____
Period	1 µs	995.7 ns to 1.004 µs	_____
Frequency	100 MHz	97.08 MHz to 103.1 MHz	_____
Period	10 ns	9.699 ns to 10.30 ns	_____

Trigger sensitivity	Test Limits	Channel 1	Channel 2	Channel 3	Channel 4
Internal trigger	25 MHz at 0.35 divisions	_____	_____	_____	_____
Channel 1 & 2	150 MHz at 1 division	_____	_____		
Channel 3 & 4	250 MHz at 1 division			_____	_____

Option 005 voltage measurement accuracy	Test Limits	Channel 1	Channel 2
Amplitude peak-to-peak	≥63.6 mVp-p	_____	_____

HEWLETT PACKARD

HP 54603B
Performance Test Record

Date_____
Serial No. _____ Test by_____
Test Interval _____ Work Order No._____
Recommended Next Testing _____ Temperature _____

Output of dc calibrator	Limits	Result
	4.990 V to 5.010 V	_____

Voltage measurement accuracy

Range	Reading	Test Limits	Channel 1	Channel 2
5 V/Div	35 V	34.04 V to 35.96 V	_____	_____
2 V/Div	14 V	13.62 V to 14.38 V	_____	_____
1 V/Div	7 V	6.808 V to 7.192 V	_____	_____
500 mV/Div	3.5 V	3.404 V to 3.596 V	_____	_____
200 mV/Div	1.4 V	1.362 V to 1.438 V	_____	_____
100 mV/Div	700 mV	680.8 mV to 719.2 mV	_____	_____
50 mV/Div	350 mV	340.4 mV to 359.6 mV	_____	_____
20 mV/Div	140 mV	136.20 mV to 143.8 mV	_____	_____
10 mV/Div	70 mV	68.08 mV to 71.92 mV	_____	_____
5 mV/Div	35 mV	33.08 mV to 36.92 mV	_____	_____
2 mV/Div	14 mV	12.08 mV to 15.92 mV	_____	_____

Bandwidth	Test Limits	Channel 1	Channel 2
	≤±3 dB	_____	_____

Horizontal Δt and 1/Δt accuracy

	Reading	Test Limits	Results
Frequency	10 kHz	9.959 kHz to 10.04 kHz	_____
Period	100 µs	99.59 µs to 100.4 µs	_____
Frequency	1 MHz	995.7 kHz to 1.004 MHz	_____
Period	1 µs	995.7 ns to 1.004 µs	_____
Frequency	50 MHz	49.25 MHz to 50.77 MHz	_____
Period	20 ns	19.70 ns to 20.30 ns	_____

Trigger sensitivity	Test Limits	Channel 1	Channel 2
Internal trigger	25 MHz at 0.35 divisions	_____	_____
	60 MHz at 1 division	_____	_____
		External	
External trigger	60 MHz at 100 mV p-p	_____	
	25 MHz at 50 mV p-p	_____	

Adjusting the Oscilloscope

This section explains how to adjust the oscilloscope so that it is at optimum operating performance. You should perform the hardware adjustments periodically as indicated below.

- Hardware at 12 months or 2,000 hours of operation
- Firmware at 6 months or 1000 hours of operation, or if ambient temperature is greater than 10 °C from the calibration temperature, or if the user desires to maximize the measurement accuracy

The amount of use, environmental conditions, and your past experience with other instruments can help you to determine if you need a shorter adjustment interval.

Make sure you allow the oscilloscope to warm up for at least 30 minutes before you start the adjustments.

WARNING

SHOCK HAZARD!
The maintenance described in this section is performed with power supplied to the oscilloscope and with the protective covers removed. Only trained service personnel who are aware of the hazards involved should perform the maintenance. Whenever possible, perform the procedures with the power cord removed from the oscilloscope. Read the safety summary at the back of this book before proceeding. Failure to observe safety precautions may result in electric shock.

CAUTION

Do not disconnect any cables or remove any assemblies with the power applied to the oscilloscope, or damage to the oscilloscope can occur.

CAUTION

ELECTROSTATIC DISCHARGE (ESD) can damage electronic components. When using any of the procedures in this chapter you should use proper ESD precautions. As a minimum, you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD strap.

To adjust the power supply

On the power supply there is only one adjustment and that is for the +5.1 V. The other voltages are based on the +5.1 V adjustment. In this procedure you use a multimeter to measure the +5.1 V, and if necessary, you adjust the supply to within tolerance.

Table 4-12 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Digital multimeter	0.1 mV resolution, accuracy ±0.05%	HP 34401A

1 Set up the oscilloscope for the voltage adjustment.
   - **a** Turn off the oscilloscope and disconnect the power cord.
   - **b** Remove the cover from the oscilloscope.
   - **c** Place the oscilloscope on its side.
   - **d** Connect the negative lead of the digital multimeter to a ground point on the oscilloscope.
   - **e** Reconnect the power cord and turn on the oscilloscope.

2 Measure the power supply voltages at L1, L2, and L3 on the system board.

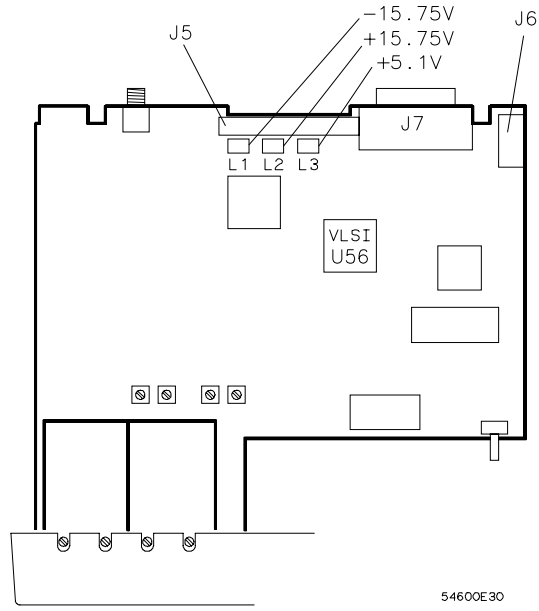
The test points are not marked on the system board; see figure below for location of test points.

Make sure that the voltage measurements are within the following tolerances.

Table 4-13 **Power Supply Voltage Tolerances**

+5.1 V	±150 mV (+4.95 V to +5.25 V)
+15.75 V	±787 mV (+14.96 V to +16.54 V)
– 15.75 V	±787 mV (–14.96 V to –16.54 V)

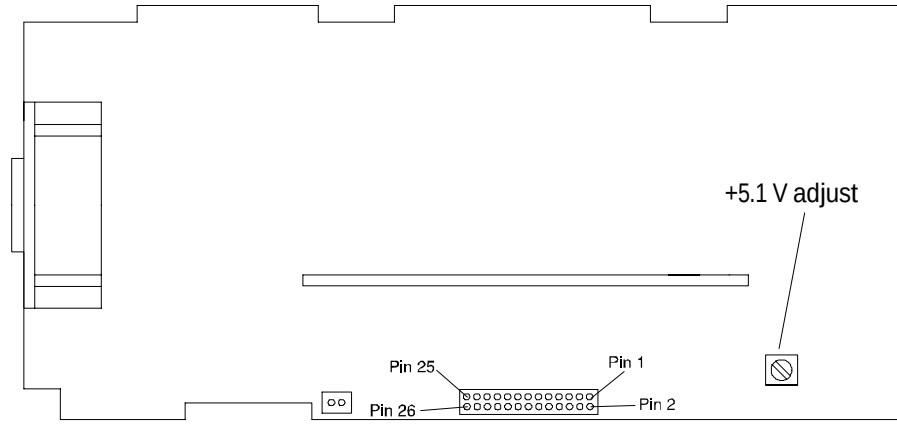
Figure 4–1



Low Voltage Power Supply voltage test points (bottom side of oscilloscope

If the +5.1 V measurement is out of tolerance, adjust the +5.1 V adjustment on the power supply. The ±15.75 V supplies are not adjustable and are dependent upon the +5.1 V supply. If adjusting the power supply does not bring all the voltages within tolerance, see "Troubleshooting the Oscilloscope," on page 4–40.

Figure 4–2



Low Voltage Power Supply adjustment location (top side of oscilloscope

To perform the self-calibration

In this procedure you load the default calibration factors to give a known starting point for the firmware calibration. *However, once the default calibration factors are loaded, you must perform the remainder of the firmware calibration to maintain the accuracy of the oscilloscope.*

Table 4-14 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Pulse generator	100 kHz, 1 V p-p, rise time <5 ns	HP 8112A
Cable	BNC, 3 feet	HP 10503A
Cable	BNC, 9 inches, Qty 2	HP 10502A
Adapter	BNC tee (m) (f) (f)	HP 1250-0781
Adapter	BNC (f-f)	HP 1250-0080
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1 Check the rear panel DC CALIBRATOR output level.

If you are not sure how to check the DC CALIBRATOR, see "To check the output of the DC CALIBRATOR," on page 4–6.

2 Load the default calibration factors.

a Set the rear-panel **CALIBRATION** switch to **UNPROTECTED** (up position).

b Press `Print/Utility` , then press the **Self Cal Menu** softkey.

c Press the **Load Defaults** softkey.

Self-calibration hint

Thie instrument is self-calibrated at the factory. However, it should be self-calibrated again in its working environment after a 30-minute warmup to obtain the best accuracy.

Vertical self cal

3 After the message "**Default calibration factors loaded**" is displayed on the lower left side of the display, press the **Vertical** softkey.

4 Follow the instructions on the display, then press the **Continue** softkey.

The display prompts instruct you to connect the rear panel DC CALIBRATOR output first to channel 3, then to channel 1, then to channel 4, and finally to channel 2. (Channels 1 and 2 only on the HP 54600B and HP 54603B.)

5 After the message "**Press Continue to return to calibration menu**" appears on the display, press the **Continue** softkey.

6 Connect a pulse generator set to 100 kHz and 1 V p-p and with a rise time less than 5 ns to channels 1 and 2. Place the feedthrough at the BNC tee. Make sure you use the HP 10502A cables to ensure equal cable lengths.

Delay self cal

7 Press the **Delay** softkey, then follow the instructions on the display.

The display will instruct you to connect the signal simultaneously to channels 1 and 2, 1 and 3, 1 and 4, 2 and 4, 2 and 3, and finally to 3 and 4.

8 Set the rear-panel **CALIBRATION** switch to **PROTECTED**.

To adjust the low-frequency compensation

In this procedure you adjust the low-frequency compensation adjustment for each channel.

Table 4-15 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Square wave generator	30 kHz at about 3 Vp-p	HP 8112A
Feedthrough	50 Ω, BNC (m) and (f)	HP10100C
Cable	BNC	HP 10503A

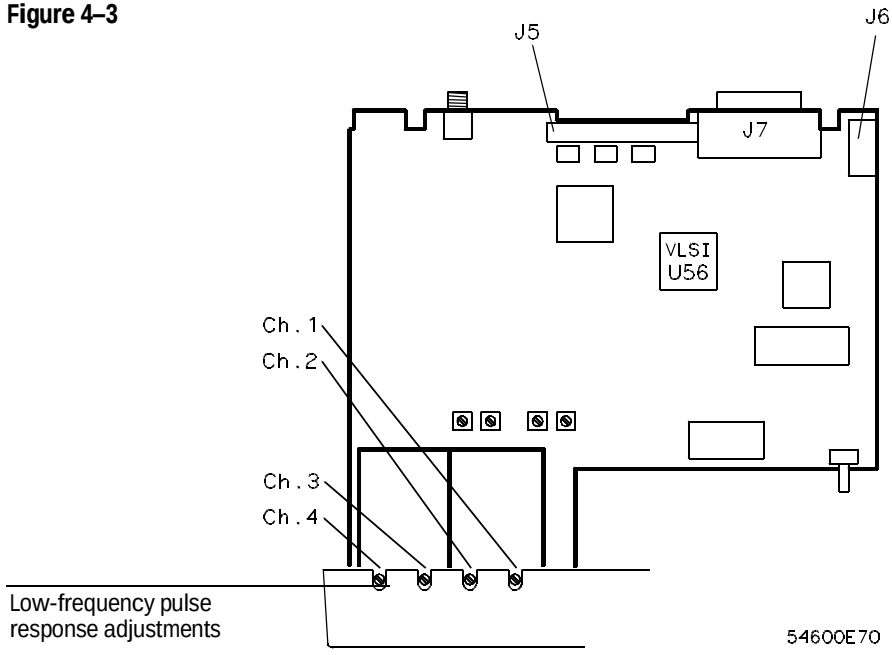
1. Turn off the oscilloscope and disconnect the power cord.
2. Remove the cover from the oscilloscope.
3. Reconnect the power cord and turn on the oscilloscope.
4. Using the BNC cable and 50-Ω feedthrough, connect the square wave generator to channel 1.
5. Adjust the generator for about 30 kHz at about 3 Vp-p.
6. Press `Autoscale` .
7. Set channel 1 to 500 mV/div.

   You must perform this adjustment on the 500 mV range.
8. Adjust the output of the generator until you obtain about 5 to 6 divisions of vertical deflection.

9 Adjust the channel 1 low-frequency compensation adjustment for as flat a pulse top as possible.

10 Repeat steps 4 through 9 for channel 2 (channels 2 to 4 on the HP 54601B and HP 54602B).

Figure 4–3



Low-frequency compensation adjustment locations

To adjust the high-frequency pulse response

In this procedure you adjust the high-frequency pulse response for each channel.

Table 4-16 **Equipment Required**

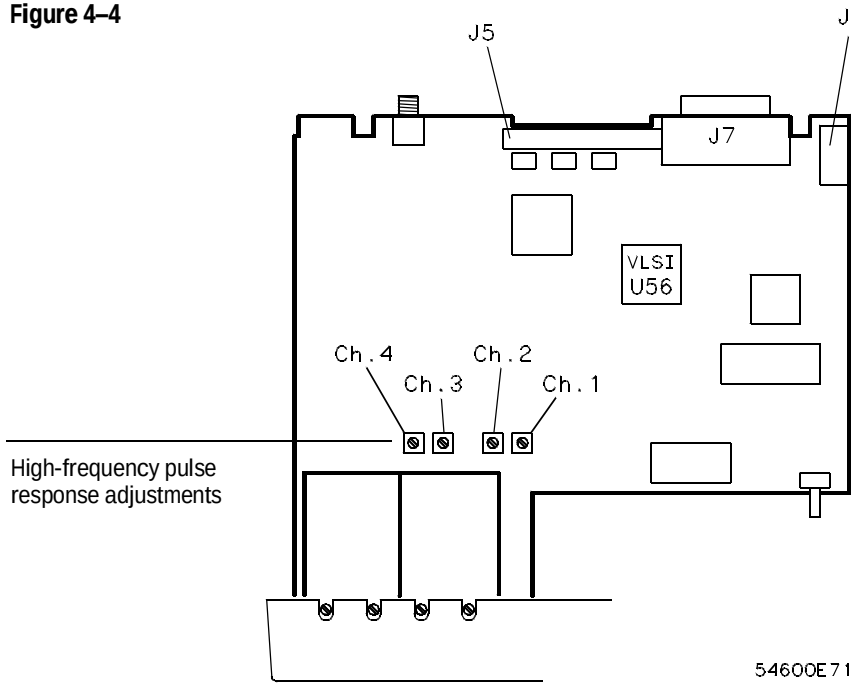
Equipment	Critical specifications	Recommended Model/Part
Pulse generator	Rise time < 875 ps	PSPL 1107B TD and PSPL 1110B Driver
Adapter	SMA (f) to BNC (m)	HP 1250-1787
Feedthrough	50 Ω, BNC (m) and (f)	HP 10100C

1. Turn off the oscilloscope and disconnect the power cord.
2. Remove the cover from the oscilloscope.
3. Reconnect the power cord and turn on the oscilloscope.
4. Connect the pulse generator to channel 1.
5. Press `Autoscale` .
6. Change the time base to 10 ns/div.
7. Press `1` , then toggle the **Vernier** softkey to On.
8. Adjust the Volt/Div until there are about 6 divisions of vertical deflection.

9 Adjust the channel 1 high-frequency response for 1.5 minor division of overshoot (6%).

10 Repeat steps 4 through 9 for channel 2 (channels 2 to 4 on the HP 54601B and HP 54602B).

Figure 4–4



High-frequency pulse response adjustment locations

To adjust the display

When to adjust the display

The display adjustments are optional and normally do not require adjustment. You should use this procedure only for the few cases when the display is obviously out of adjustment.

Table 4-16 **Equipment Required**

Equipment	Critical specifications	Recommended Model/Part
Digital multimeter	Accuracy ±0.05%, 1 mV resolution	HP 34401A

1. Turn off the oscilloscope and disconnect the power cord.
2. Remove the cover from the oscilloscope.
3. Reconnect the power cord and turn on the oscilloscope.
4. Connect the digital multimeter to the end of R901 closest to the fuse. See figure on next page.
5. Adjust +B for +14.00 V.
6. Press `Print/Utility` . Press the **Self Test** Softkey, then press the **Display** softkey.
7. Adjust V.HO (vertical hold) for vertical synchronization.
8. Set the intensity control (on the front panel) to mid-range.
9. Adjust Sub Bri (sub bright) to the lowest setting so that the half bright blocks on the display are visible.
10. Increase the intensity control to a comfortable viewing level.

    This is usually about 3/4 of its maximum range.

11 Adjust HB Cont (half bright contrast) for the best contrast between the half bright and full bright blocks.

You can readjust Sub Bri, intensity control, and HB Cont to suit your individual preference.

12 Press any key to continue to the next test pattern. Then, adjust H.Hold (horizontal hold) to center the display horizontally.

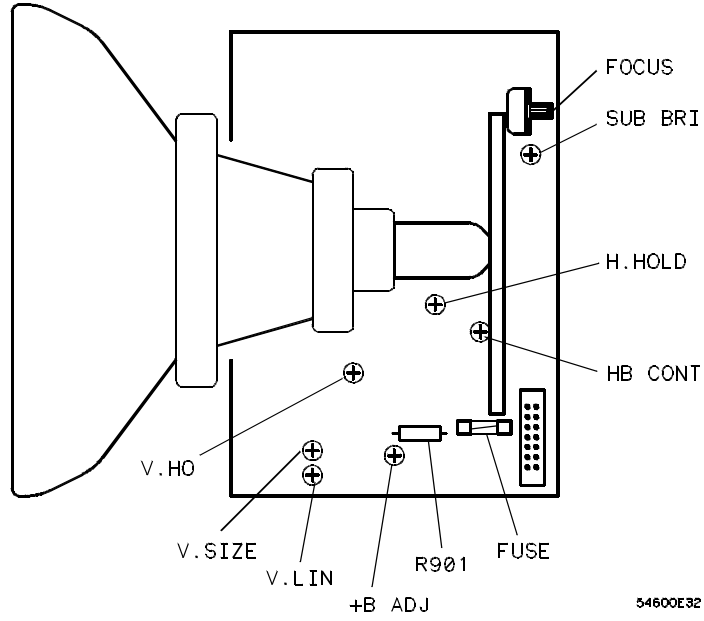
13 Adjust Focus for the best focus.

14 Press any key to continue to the normal display pattern. Then adjust V.Lin (vertical linearity) for equal sizing of all four corner squares.

15 Adjust V.Size (vertical size) to center the display vertically at the maximum allowable size without losing the text.

Adjustments V.Lin and V.Size interact so you may need to readjust sizing and vertical centering of the display.

Figure 4–5



Display board adjustment locations

To adjust the Option 005 offset (R15) (HP 54602B only)

The oscilloscope must be calibrated before performing this adjustment. Refer to "To perform the self-calibration" on page 4–31.

Table 4-17 Equipment Required

Equipment Required	Critical Specification	Recommended Model/Part
Digital Multimeter	0.1 mV resolution, accuracy ±0.05%	HP 34401A
Adapter	BNC (m) to dual banana post	HP 10110B

1 Set up the oscilloscope for the voltage adjustment.
   - **a** Turn off the oscilloscope and disconnect the power cord.
   - **b** Remove the cabinet from the oscilloscope.
   - **c** Connect the negative lead of the digital multimeter to a ground point on the oscilloscope.
   - **d** Connect the oscilloscope rear-panel VERT OUT connector to the voltage inputs of the digital multimeter (DMM) using the DMM's test leads and the BNC to dual banana post adapter.
   - **e** Reconnect the power cord and turn on the oscilloscope
   - **f** Setup the digital multimeter for a DC voltage measurement.
   - **g** Press the `Setup` front panel key on the oscilloscope.
   - **h** Press the **Default Setup** softkey on the oscilloscope.

2 Adjust R15 (below VERT OUT connector) on the Option 005 PC board so that the measured voltage on the digital multimeter is 0 volts ±1 mV.

If adjusting R15 does not bring the voltage within tolerance, see "To troubleshoot Option 005" on page 4–48.

Troubleshooting the Oscilloscope

The service policy for this instrument is replacement of defective assemblies. The following procedures can help isolate problems to the defective assembly.

WARNING

SHOCK HAZARD!
The maintenance described in this section is performed with power supplied to the oscilloscope and with the protective covers removed. Only trained service personnel who are aware of the hazards involved should perform the maintenance. Whenever possible, perform the procedures with the power cord removed from the oscilloscope. Read the safety summary at the front of this book before proceeding. Failure to observe safety precautions may result in electrical shock.

CAUTION

Do not disconnect any cables or remove any assemblies with the power applied to the oscilloscope, or damage to the oscilloscope can occur.

CAUTION

ELECTROSTATIC DISCHARGE (ESD) can damage electronic components. When using any of the procedures in this chapter you should use proper ESD precautions. As a minimum, you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD strap.

The following equipment is needed for troubleshooting the oscilloscope.

Table 4-18 **Equipment Required**

Equipment	Critical specifications	Recommended model/part
Digital multimeter	Accuracy ±0.05%, 1 mV resolution	HP 34401A
Oscilloscope	100 MHz	HP 54600B
Probe	10:1 division ratio	HP 10432A
Dummy load [1]	Compatible with power supply	see note 1 below

[1] See page 4–41 to construct your own dummy load.

To construct your own dummy load

1. Obtain a connector compatible with the connector on the Low Voltage Power Supply.
2. Connect the following load resistors to the connector.

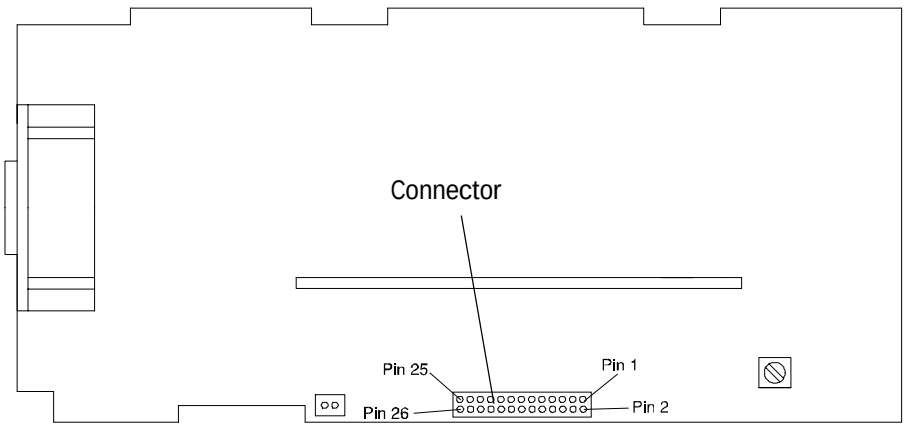
   +5.1 V requires a 3 A load, 1.7 Ω and 15 W on pin 15, 17, or 19.

   +15.75 V requires a 1.3 A load, 12.2 Ω and 20.5 W on pin 11 or 13.

   With the fan operating, –15.75 V requires a 0.6 A load, 26.25 Ω and 9.5 W on pin 5 or 7.

   Without the fan operating, –15.75 V requires a 0.8 A load, 26.25 Ω and 13 W on pin 5 or 7.
3. Connect the other end of the resistors to ground pins 2, 4, 6, and 8.

Figure 4–6



Low Voltage Power Supply connector pinout

To check out the oscilloscope

1 Is there an interface module connected to the oscilloscope?

If yes, do the following steps. If not, go to step 2.

- **a** Turn off the oscilloscope.
- **b** Remove the module.
- **c** Turn on the oscilloscope, then check for the failing symptom.

  If the failing symptom disappears, replace the module. If not, go to step 2.

2 Disconnect any external cables from the front panel.

3 Disconnect the power cord, then remove the cover.

4 Connect the power cord, then turn on the oscilloscope.

If the display comes on after a few seconds, (HP logo and copyright text, followed by a graticule with text at top of the display) go to "To check the Low Voltage Power Supply," on page 4–45. If after checking the Low Voltage Power Supply the voltages are within the test limits, go to step 8. If not, go to step 6. If the display did not come on, do the steps below.

- **a** Check the intensity knob setting to see if it's set too low.
- **b** If there is still no display, disconnect the power cord.
- **c** Check all cable connections.
- **d** Go to "To check the Low Voltage Power Supply," on page 4–45.

  If the voltages are within the limits go to step 5. If not, go to step 6.

5 Disconnect the display cable, then check the following signals on the system board.

Table 4-18 **Signals at U56**

	Signal	Frequency	Pulse width	Voltage
U16 Pin 7	DE	19.72 kHz	38.0 µs	2.6 Vp-p
U16 Pin 24	Hsync	19.72 kHz	3.0 µs	5.0 Vp-p
U9 Pin 2	Vsync	60.00 Hz	253.5 µs	5.2 Vp-p

If the signals are good, replace the display assembly. If not, replace the system board.

6 Disconnect the Low Voltage Power Supply ribbon cable from the display board.

7 Measure the power supply voltages again (steps 1-3).

If the voltages are within the test limits, replace the display assembly. If not, do the steps below.

a Disconnect the power cord.

b Disconnect the ribbon cable from the power supply.

c Connect the dummy load to the power supply connector.

d Connect the power cord, then measure the power supply voltages again (see new tolerances below).

+5.1 V (4.95 V to +5.25 V)
+15.75 V (+15 V to +16.5 V)
−15.75 V (−15 V to −16.5 V)

If the voltages are now within the test limits, replace the system board. If not, replace the power supply.

8 Is the fan running?

If yes, go to "To run the internal self-tests," on page 4–46. If not, do the steps below.

The Low Voltage Power Supply has a thermal cut-out circuit. If the fan is defective, the Low Voltage Power Supply shuts down when it gets too hot for safe operation.

a Disconnect the fan cable from the power supply.

b Measure the fan voltage at the connector on the power supply.

If the fan voltage is –8.3 Vdc, replace the fan. If not, replace the power supply.

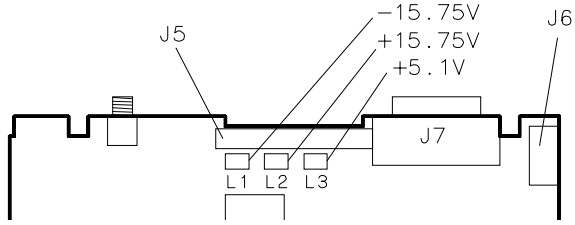
To check the Low Voltage Power Supply

1. Disconnect the power cord, then set the oscilloscope on its side.
2. Connect the negative lead of the multimeter to a ground point on the oscilloscope. Connect the power cord and turn on the oscilloscope.
3. Measure the power supply voltages at L1, L2, and L3 on the system board.

Table 4-19 **Power Supply Voltage Tolerances**

Supply Voltage	Tolerance
+5.1 V	±150 mV (+4.95 V to + 5.25 V)
+15.75 V	±787 mV (+14.96 V to +16.54 V)
–15.75 V	±787 mV (–14.96 V to –16.54 V)

Figure 4–7



Low Voltage Power Supply voltage test points

If the +5.1 V measurement is out of the test limits, adjust the +5.1 V adjustment on the power supply. The ±15 V supplies are not adjustable and are dependent upon the +5.1 V supply.

Blown fuse

If the fuse is blown in the power supply, the power supply is defective. Replace the power supply.

To run the internal self-tests

1 Perform the keyboard test.

- **a** Press `Print/Utility` .
- **b** Press the **Self Tst** softkey, then press the **Keyboard** softkey.

  A pictorial diagram of the front panel will appear on the display.
- **c** Press each key, and notice that when you press a key a corresponding block on the display fills in.
- **d** Rotate the knobs (except the intensity) and notice that an arrow appears on the display that points in the direction you rotate the knob.
- **e** Do all the keys and knobs work?

  If yes, Press the **Stop** softkey two or three times (the display indicates how many times), then go to step 2. If not, replace the keyboard and keyboard assembly.

2 Check the output level of the DAC.

- **a** Press the **DAC** softkey.
- **b** Connect a multimeter to the rear panel DC CALIBRATOR connector.

  The multimeter should read 0 V ±500 µV.
- **c** Press any key to continue.

  The multimeter should read 5 V ±10 mV.
- **d** Are the DAC voltages correct?

  If yes, press any key to continue. If not, replace the system board.

3 Perform the ROM test

- **a** Press the **ROM** softkey.
- **b** Does the display message say **Test Passed**?

  If yes, press any key to continue. If not, (the display message says **Test Failed**) replace the system board.

4 Perform the RAM test.

a Press the **RAM** softkey.

b Does the display message say **Test Passed**?

If yes, press any key to continue. If not, (the display message says **Test Failed**) replace the system board.

5 Perform the display test.

a Press `Print/Utility` .

b Press the **Self Tst** softkey, then press the **Display** softkey.

c Do the half bright and full bright squares appear?

If yes, continue with the steps below. If not, replace the display.

d Press any key to continue.

e Do squares appear in the four corners?

If yes, the display is good. If not, replace the display.

f Press any key to end the test.

g If you still have the failing symptom, replace the system board.

To troubleshoot Option 005 (HP 54602B only)

To isolate a malfunction to the Option 005 board, do the following:

1. Disconnect the three cables that connect the Option 005 board to the system board.
2. Verify proper oscilloscope operation, as described in this chapter.
3. If the oscilloscope passes the performance verification and the malfunction still occurs when the Option 005 board is reconnected, then you should replace the Option 005 board.

Replacing Parts in the Oscilloscope

This section contains instructions for removing and ordering replaceable assemblies. Also in this section is a parts list for the assemblies and hardware of the oscilloscope that you can order from Hewlett-Packard.

Before working on the oscilloscope, read the safety summary at the back of this book.

WARNING Hazardous voltages are on the CRT, power supply, and display sweep board. To avoid electrical shock, disconnect the power cord from the oscilloscope. Wait at least three minutes for the capacitors in the oscilloscope to discharge before you begin disassembling the oscilloscope.

CAUTION Do not replace assemblies with the oscilloscope turned on or damage to the components can occur.

CAUTION ELECTROSTATIC DISCHARGE (ESD) can damage electronic components. When using any of the procedures in this chapter you should use proper ESD precautions. As a minimum, you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD strap.

To replace an assembly

Refer to the exploded view of the oscilloscope, figure 4–11 (figure 4–12 for Option 005 board), for details on how the oscilloscope fits together. To install an assembly, follow the instructions in reverse order.

You will need the following tools to disassemble the oscilloscope:

- T15 TORX driver to remove the oscilloscope from the cabinet and to remove the fan.
- T10 TORX driver to remove the assemblies from the deck.
- Flat-blade screwdriver to remove the optional modules and the pouch.
- 9/16-inch nut driver or wrench to remove BNC nut.

1 Remove the oscilloscope from the cabinet.

a Turn off the oscilloscope and disconnect the power cable.

b If a module is installed, remove it from the oscilloscope.

c Using the T15 TORX driver, remove the two screws from the rear of the cabinet.

d Using your thumbs, gently push on the two rear-panel connectors to slide the oscilloscope out of the cabinet.

2 Remove the faulty assembly.

You can remove any of the following six assemblies: fan, front panel, display, system board, power supply, and keyboard.

To remove the fan

1. Disconnect the fan cable from the power supply board.
2. Using the T15 TORX driver, remove the three screws that hold the fan to the deck.

To remove the front panel

1. Remove the intensity knob by pulling straight out.
2. Disconnect the keyboard ribbon cable from the system board.
3. Use a screwdriver to release retainer tab A, and your finger to release retainer tab B. See figure on next page.

Releasing front panel from deck of intrument

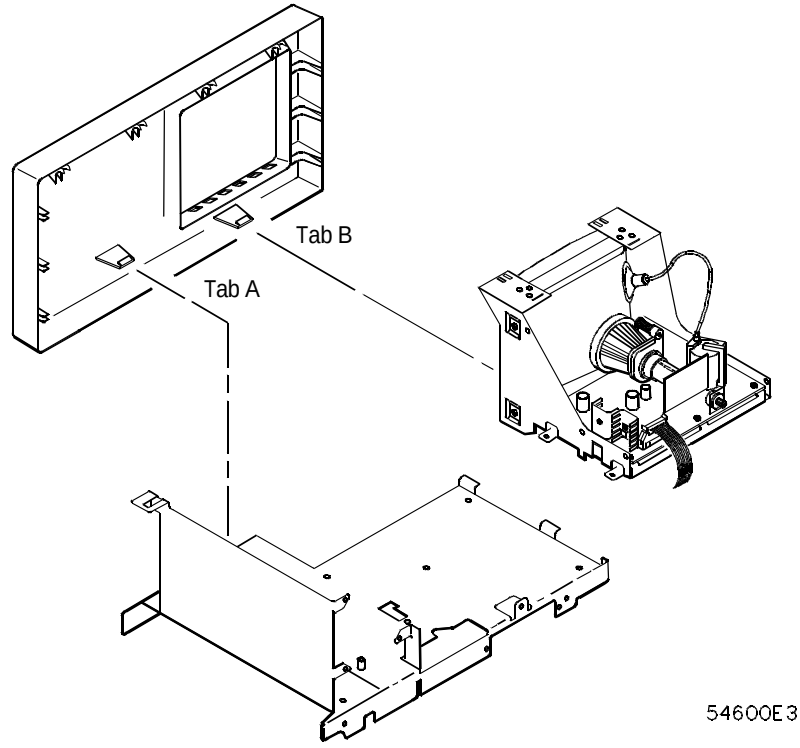
When tab B is released, be careful that the sheet metal tab of front-panel ground input clears the softkey circuit board. The circuit board may be depressed slightly with a screwdriver to avoid damage to the circuit board.

4. Rotate the front panel out until the bottom clears the rear of the assembly, then lift the front panel to free the hooks on top.

When installing the front panel, make sure that the power switch shaft is aligned with its mating hole in the front panel.

The front panel swings in to engage the two retainer tabs. Before attempting to engage the retainer tabs, make sure that the six hooks on top of the front panel are fully engaged with their mating holes in the sheet metal.

Figure 4–8



Removing the front panel

To remove the display

1. Remove the front panel.
2. Disconnect the ribbon cable and the calibration cable from the display.
3. Using the T10 TORX driver, remove the two screws that hold the display to the deck.

   Make sure that when you reinstall these screws that you use the correct parts. If longer screws are used, they can short the system board to ground.
4. As you lift the display, rotate it off the two tabs on the side of the deck.

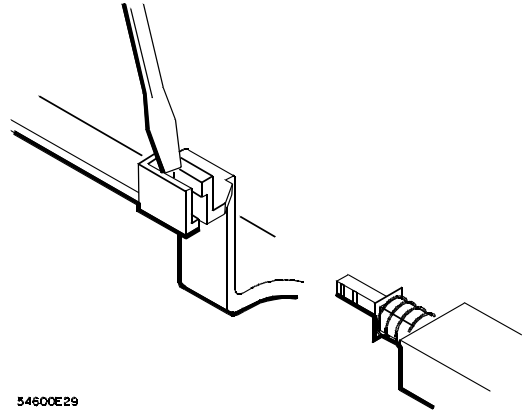
To remove the system board

1. Using the T10 TORX driver, remove the eight screws that hold the system board to the deck (two of the screws are in the attenuator covers).
2. Remove the two screws from the rear-panel interface connector and the nut from the rear-panel BNC.
3. Disconnect the three ribbon cables and the calibration cable.
4. As you remove the system board, rotate the system board so that the BNCs clear the front panel.

Power supply

1. Remove the fan.
2. Disconnect the ground wire (green wire with the yellow stripe) from the deck.
3. Disconnect the ribbon cable from the power supply board.
4. Use a screw driver to gently unhook the latch that holds the white shaft to the power switch, then disconnect the shaft from the power switch. After you disconnect the shaft, make sure you position it in the recess along the side of the display bracket.

Figure 4–9



Removing the power switch shaft

5. Using the T10 TORX driver, remove the screw holding the power supply board to the deck.
6. Slide the power supply board towards the front panel about a half an inch. Slip the keyhole slots on the power supply board off of the pins on the deck.

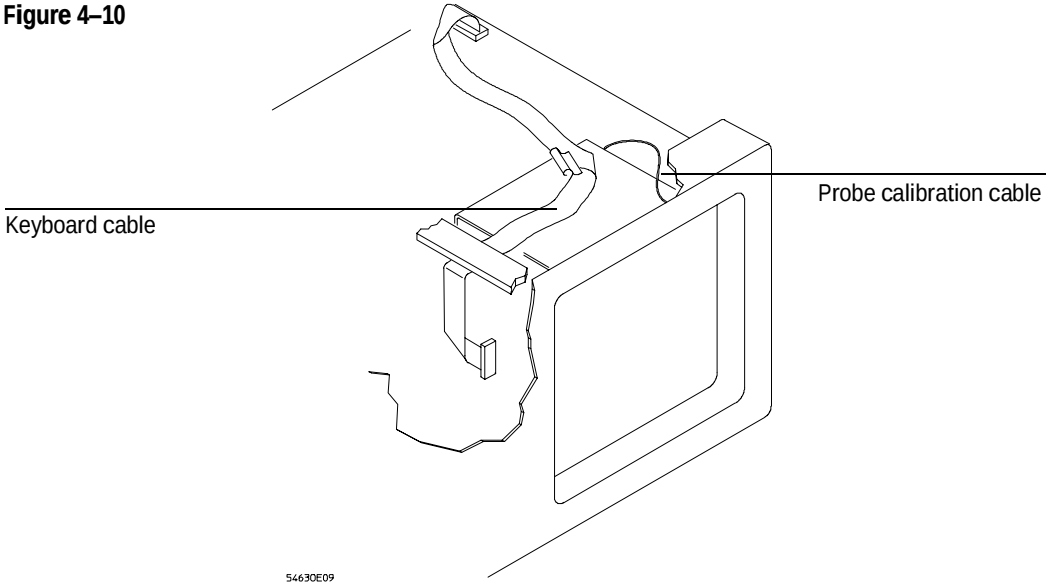
Keyboard

1. Remove the front panel.
2. Remove all the knobs by pulling straight out.
3. Flex the bezel of the front panel to unsnap the small keyboard under the display opening.
4. Using the T10 TORX driver, remove the three screws from the large keyboard.

   Make sure that when you reinstall these screws that you use the correct parts. If longer screws are used, they can damage the front-panel label.
5. Press down on the top of the keyboard, and rotate the bottom of the keyboard out.

   When installing the keyboard, make sure that the probe calibration cable is kept away from the keyboard cable or noise can occur in the probe adjust signal. See figure below for positioning the keyboard cable.

Figure 4–10



Positioning the keyboard cable

To remove the handle

- Rotate the handle down until it is just past the last detent position (about 1/2 inch before the handle touches the bottom of the oscilloscope), then pull the sides of the handle out of the cabinet.

To remove the Option 005 board

1. Remove the oscilloscope from the cabinet.
   - **a** Turn off the oscilloscope and disconnect the power cable.
   - **b** If a module is installed in the oscilloscope, remove it.
   - **c** Using the T15 TORX driver, remove the two screws from the rear of the cabinet.
   - **d** Using your thumbs, gently push on the two rear-panel connectors to slide the oscilloscope out of the cabinet.
2. Remove the faulty Option 005 board.
   - **a** Using a T10 TORX driver, remove the two screws that lock the Option 005 board to the chassis.
   - **b** Slide the board back away from the front panel to release it from the keyholes.
   - **c** Disconnect the three cables attached to the Option 005 board.
   - **d** Remove the board from the keyholes, and from the oscilloscope.

To order a replacement part

The system board is part of an exchange program with Hewlett-Packard. The exchange program allows you to exchange a faulty assembly with one that has been repaired and performance verified by Hewlett-Packard.

After you receive the exchange assembly, return the defective assembly to Hewlett-Packard. A United States customer has 30 days to return the defective assembly. If you do not return the faulty assembly within the 30 days, Hewlett-Packard will charge you an additional amount. This amount is the difference in price between a new assembly and that of the exchange assembly. For orders not originating in the United States, contact your nearest Hewlett-Packard Sales Office for information.

- To order a part in the material list, quote the Hewlett-Packard part number, indicate the quantity desired, and address the order to your nearest Hewlett-Packard Sales Office.

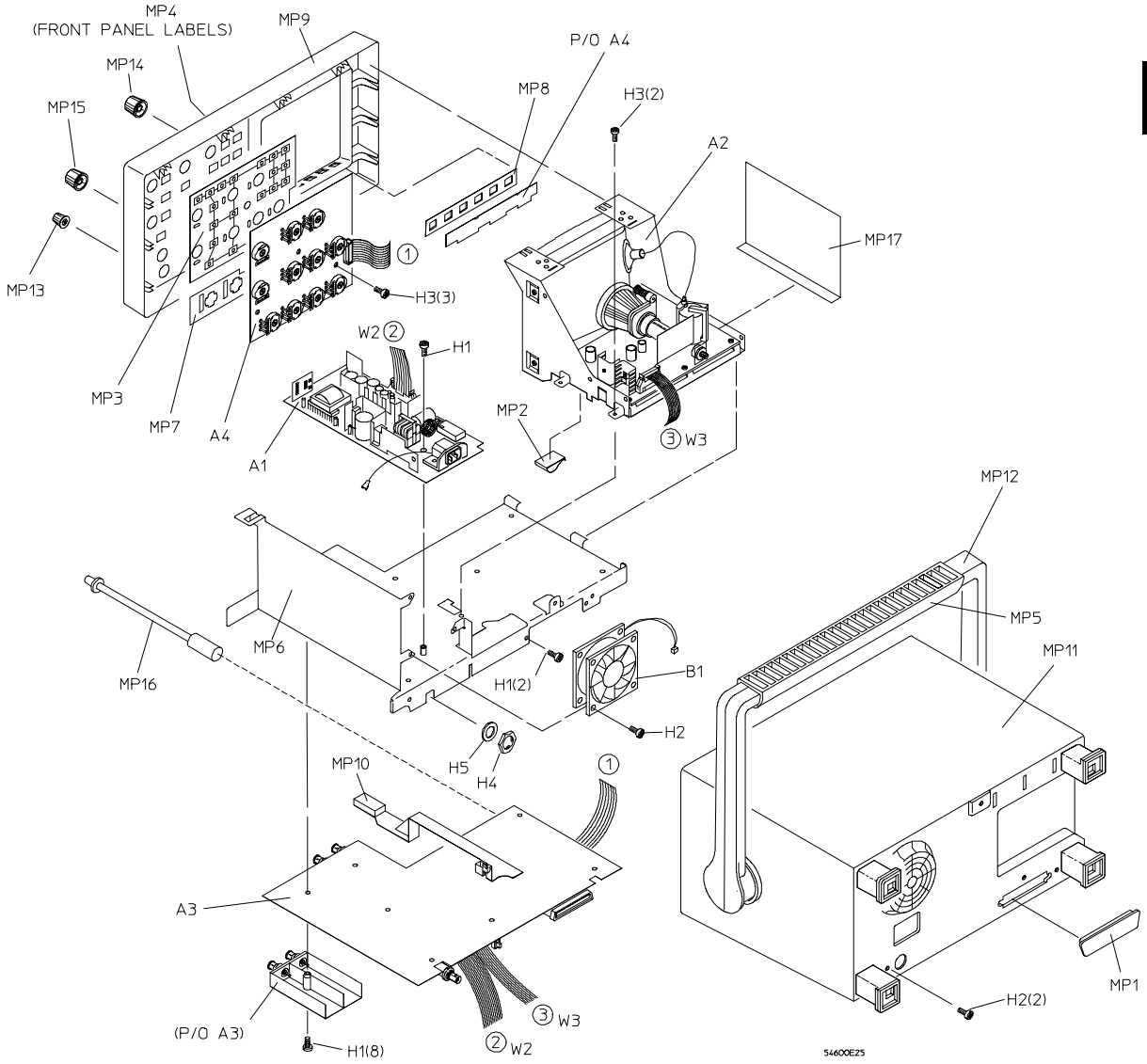
- To order a part not listed in the material list, include the model number and serial number of the oscilloscope, a description of the part (including its function), and the number of parts required. Address the order to your nearest Hewlett-Packard Sales Office.

- To order using the direct mail order system, contact your nearest Hewlett-Packard Sales office.

  Within the USA, Hewlett-Packard can supply parts through a direct mail order system. The advantages to the system are, direct ordering and shipment from the HP Parts Center in Mountain View, California. There is no maximum or minimum on any mail order. (There is a minimum amount for parts ordered through a local Hewlett Packard Sales Office when the orders require billing and invoicing.) Transportation costs are prepaid (there is a small handling charge for each order) and no invoices.

  In order for Hewlett-Packard to provide these advantages, a check or money order must accompany each order. Mail order forms and specific ordering information are available through your local Hewlett-Packard Sales Office. Addresses and telephone numbers are located in a separate document shipped with the instrument.

Figure 4–11



Exploded view of oscilloscope

Table 4-20 **Replaceable Parts**

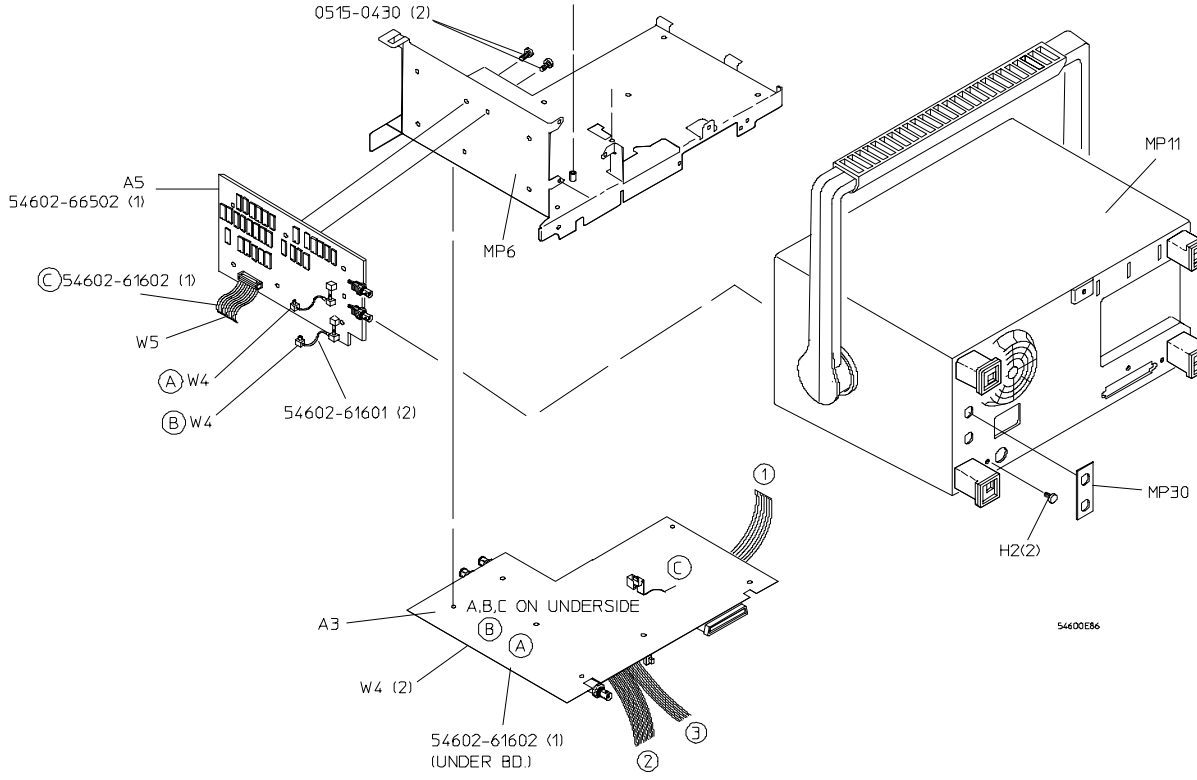
Reference Designator	HP Part Number	Qty	Description
A1	0950-2125	1	Power supply assembly
A2	2090-0316	1	Display assembly
A3	54600-66506	1	System board (HP 54600B only)
A3	54600-69506		Exchange system board (HP 54600B only)
A3	54601-66506	1	System board (HP 54601B only)
A3	54601-69506		Exchange system board (HP 54601B only)
A3	54602-66506	1	System board (HP 54602B only)
A3	54602-69506		Exchange system board (HP 54602B only)
A3	54603-66506	1	System board (HP 54603B only)
A3	54603-66506		Exchange system board (HP 54603B only)
A4	54600-66502	1	Keyboard (HP 54600B and HP 54603B only)
A4	54601-66502	1	Keyboard (HP 54601B and HP 54602B only)
B1	3160-1006	1	Fan
H1	0515-0372	11	Machine screw M3 X 8
H2	0515-0380	5	Machine screw M4 X 10
H3	0515-0430	5	Machine screw M3 X 6
H4	1250-2075	1	RF connector nut, 0.5 inch
H5	2190-0068	1	Lock washer
MP1	1251-2485	1	Connector dust cover
MP2	1400-1581	1	Cable clamp
MP3	54600-41901	1	Large keypad (HP 54600B and HP 54603B only)
MP3	54601-41901	1	Large keypad (HP 54601B and HP 54602B only)
MP4	54600-94306	1	Front-panel label (HP 54600B only)
MP4	54601-94306	1	Front-panel label (HP 54601B only)
MP4	54602-94301	1	Front-panel label - China (HP 54602B only)
MP4	54602-94306	1	Front-panel label (HP 54602B only)
MP4	54603-94301	1	Front-panel label (HP 54603B only)
MP5	54600-94307	1	Handle Label (HP 54600B only)
MP5	54601-94307	1	Handle Label (HP 54601B only)
MP5	54602-94307	1	Handle Label (HP 54602B only)
MP5	54603-94303	1	Handle Label (HP 54603B only)
MP6	54601-00102	1	Deck
MP7	54601-07101	1	EMI gasket

Reference Designator	HP Part Number	Qty	Description
MP8	54601-41902	1	Small rubber keypad
MP9	54645-42202	1	Front panel
MP10	54601-43701	1	Power-switch shaft
MP11	54601-64401	1	Cabinet (comes with handle and feet installed)
MP12	54601-44901	1	Handle
MP13	54601-47401	7	Small knob (HP 54600 has 6)
MP14	54601-47402	3	Large knob
MP15	54601-47403	1	Intensity knob
MP16	54601-47404	1	Small knob (dark)
MP17	5081-7741	1	Safety shield sheet
W1	8120-1521	1	Standard power cord
W1	8120-1703		Power cord option 900, United Kingdom
W1	8120-0696		Power cord option 901, Australia
W1	8120-1692		Power cord option 902, Europe
W1	8120-0698		Power cord option 904, 250 V, USA/Canada
W1	8120-2296		Power cord option 906, Switzerland
W1	8120-2957		Power cord option 912, Denmark
W1	8120-4600		Power cord option 917, Africa
W1	8120-4754		Power cord option 918, Japan
	Option 101		**Accessory pouch and front-panel cover.**
	5041-9411		Pouch
	54601-44101		Front-panel cover

Attenuator covers replacement parts (these are a part of the A3 system board)

54601-04101	Channel attenuator cover (one used on HP 54600B and HP 54603B, two used on HP 54601B and HP 54602B)
0515-0667	M3 x 25 machine screw that holds attenuator cover to system board
54645-21701	Spacer that goes between system board and attenuator cover. M3 x 25 machine screw goes through spacer.

Figure 4-12



Exploded view of Option 005 and related oscilloscope parts

Table 4-21 **Option 005 Replaceable Parts**

Reference Designator	HP Part Number	Qty	Description
A3	*	1	System Board (part of standard instrument)
A5	54602-66502	1	Video Trigger Board
H2	0515-0380	5	Machine screw M4 X 10 (part of standard instrument)
H3	0515-0430	7	Machine screw M3 X 6 (+2 screws for Option 005)
MP6	54601-00101	1	Deck (part of standard instrument)
MP11	54602-64402	1	Cabinet (comes with handle and feet installed – replaces standard cabinet)
MP30	54602-94305	1	Label, rear panel video trigger
W4	54602-61601	2	RF cable
W5	54602-61602	1	Ribbon cable
	HP 11094B	1	**75Ω Termination**

* See the oscilloscope Replaceable Parts table for the HP part number of the A3 System Board.

Performance Characteristics

Performance Characteristics

The performance characteristics describe the typical performance of the oscilloscope. You will notice that some of the characteristics are marked as tested, these are values that you can verify with the performance tests under "Verifying Oscilloscope Performance," on page 4–5.

Vertical System

All channels

Bandwidth[1]

HP 54600B and HP 54601B

dc to 100 MHz –3 dB
ac coupled, 10 Hz to 100 MHz –3 dB

HP 54602B

dc to 100 MHz –3 dB (1, 2, & 5 mV/div)
dc to 150 MHz –3 dB (channels 1 & 2)
dc to 250 MHz –3 dB (channels 3 & 4)
ac coupled, 10 Hz to 150 MHz –3 dB (channels 1 & 2)

HP 54603B

dc to 60 MHz –3 dB
ac coupled, 10 Hz to 60 MHz

Rise time

3.5 ns (calculated, HP 54600B & HP 54601B)
<2.33 ns (calculated, channels 1 & 2, HP 54602B)
<1.4 ns (calculated, channels 3 & 4, HP 54602B)
5.8 ns (calculated, HP 54603B)

Dynamic range ±32 V or ±8 divisions, whichever is less

Math functions Channel 1 + or – channel 2

Input resistance 1 MΩ

Input capacitance ≈13 pf

⚠ **Maximum input voltage** 400 V (dc + peak ac)

[1] Tested, see "To verify bandwidth," on page 4–10.

Channels 1 and 2

Range 2 mV/div to 5 V/div (lower limit is 1 mV/div for the HP 54602B)

Accuracy[1] ±1.9% (HP 54600B, HP 54601B, and HP 54602B)
±2.4% (HP 54603B)

Verniers[1] Fully calibrated, accuracy about ±3.5%

Cursor accuracy[1, 2, 3]

Single cursor accuracy vertical accuracy ±1.2% of full scale ±0.5% of position value (HP 54602B at <10 mV/div: vertical accuracy ±2.4% of full scale ±0.5% of position value)

Dual cursor accuracy vertical accuracy ±0.4% of full scale

Bandwidth limit ≈20 MHz

Coupling Ground, ac, and dc

Inversion Channel 1 and channel 2

CMRR (common mode rejection ratio) ≈ 20 dB at 50 MHz

Channels 3 and 4

(HP 54601B & HP 54602B only)

Range 0.1 V/div and 0.5 V/div ranges

Accuracy[1] ±1.5%

Coupling Ground and dc

[1] When the temperature is within ±10 °C from the calibration temperature.
[2] Use a full scale of 16 mV for 1 mV/div range for HP 54602B.
Use a full scale of 80 mV for 2 mV/div and 5 mV/div ranges for all other scopes.
[3] Tested, see "To verify voltage measurement accuracy," on page 4–7.

Horizontal System

Sweep speeds

5 s/div to 2 ns/div main and delayed (HP 54600B, HP 54601B, HP 54602B
5 s/div to 5 ns/div main and delayed (HP 54603B)

Accuracy ±0.01% ±0.2% of full scale ±200 ps

Vernier Accuracy ±0.05%

Horizontal resolution 100 ps

Cursor accuracy[1,2] **(Δt and 1/Δt)** ±0.01% ±0.2% of full scale ±200 ps

Delay jitter 10 ppm

Pretrigger delay (negative time) ≥10 divisions

Posttrigger delay (from trigger point to start of sweep) at least 2560 divisions or 50 ms. Not to exceed 100 s.

Delayed sweep operation

Main sweep	**Delayed sweep**
5 s/div to 10 ms/div	up to 200 times main sweep
5 ms/div and faster	up to 2 ns/div

[1] Use full scale of 50 ns on 2 ns/div range.
[2] Tested, see "To verify horizontal Δt and 1/Δt accuracy," on page 4–16.

Trigger System

Internal trigger

Sensitivity[1]

HP 54600B	dc to 25 MHz	0.35 div or 3.5 mV
	dc to 100 MHz	1 div or 10 mV
HP 54601B	dc to 25 MHz	0.35 div or 3.5 mV
	dc to 100 MHz	1 div or 10 mV
HP 54602B	dc to 25 MHz	0.35 div or 3.5 mV (>5 mV/div)
		1.0 div or 2 mV (1, 2, or 5 mV/div)
	25 MHz to 100 MHz	1.5 div or 3 mV (1, 2, or 5 mV/div)
	dc to 150 MHz	1 div or 10 mV (chan 1&2)(>5 mV/div)
	dc to 250 MHz	1 div or 100 mV (chan 3&4)
HP 54603B	dc to 25 MHz	0.35 div or 3.5 mV
	dc to 60 MHz	1 div or 10 mV

Sources Channels 1, 2, 3, 4, and line on HP 54601B & HP 54602B
Channels 1, 2, line, and external on HP 54600B and HP 54603B

Coupling ac, dc, LF reject, HF reject, and noise reject
LF reject and HF reject –3 dB at ≈50 kHz

Modes Auto, Autolevel, Normal, Single, and TV

TV triggering Available on channels 1 and 2 only

TV line and field 0.5 division of composite sync for stable display

Holdoff Adjustable from 200 ns to ≈13 s

External trigger (HP 54600B and HP 54603B only)

Range ±18 V

Sensitivity[1]

HP 54600B	dc to 25 MHz	50 mV
	dc to 100 MHz	100 mV
HP 54603B	dc to 25 MHz	50 mV
	dc to 60 MHz	100 mV

Coupling dc, HF reject, and noise reject

Input resistance 1 MΩ

Input capacitance ≈13 pf

⚠ **Maximum input voltage** 400 V (dc + peak ac)

[1] Tested, see "To verify trigger sensitivity," on page 4–18.

XY Operation

Z Blanking TTL high blanks trace

Bandwidths X and Y same as vertical system

Phase difference ±3 degrees at 100 kHz

Display System

Display 7-inch raster CRT

Resolution 255 vertical by 500 horizontal points

Controls Front-panel intensity control

Graticule 8×10 grid or frame

Autostore Autostore saves previous sweeps in half bright display and the most recent sweep in full bright display.

Acquisition System

Maximum sample rate 20 MSa/s

Resolution 8 bits

Simultaneous channels Channels 1 and 2 or channels 3 and 4

Record length

Vectors off 4,000 points
Vectors on and/or single shot 2,000 points

Maximum update rate

Vectors off 1,500,000 points/sec
Vectors on 60 full screens/sec, independent of the number of waveforms being displayed

Single-shot bandwidth 2 MHz single channel, 1 MHz dual channel

Peak detect 50 ns glitch capture (100 ns dual channel) from 5 s/div to 50 µs/div

Average Number of averages selectable at 8, 64, and 256

Roll Mode At sweep speeds of 200 ms/div and slower, waveform data moves across the display from right to left with no dead time.

Display can be either free-running (non-triggered) or triggered to stop on a trigger event.

Advanced Functions

Automatic measurements (measurements are continuously updated)

Voltage Vavg, Vrms, Vp-p, Vtop, Vbase, Vmin, Vmax
Time Frequency, period, + width, – width, duty cycle, rise time, and fall time
Cursors Manually or automatically placed

Setup functions

Autoscale Sets vertical and horizontal deflections and trigger level forsignals with a frequency ≥50 Hz, duty cycle >1%, and voltage level channels 1 and 2 >20 mVp-p, channels 3 and 4 >100 mVp-p, external trigger (HP 54600B and HP 54603B only) >100 mVp-p.
Save/Recall 16 front-panel setups
Trace memory Two volatile pixel memories

Power Requirements

Line voltage range 100 Vac to 240 Vac

Line voltage selection Automatic

Line frequency 45 Hz to 440 Hz

Maximum power consumption 220 VA

General

Environmental characteristics

The instrument meets or exceeds the environmental requirements of MIL-T-28800D for Type III, Class 3, Style D equipment as described below.

Ambient temperature (Tested to MIL-T-28800D paragraphs 4.5.5.13 option 2 and 4.5.5.14)

Operating –10 °C to +55 °C
Nonoperating –51 °C to +71 °C

Humidity (tested to Hewlett-Packard environmental specification section 758 paragraphs 4.0, 4.1, and 4.2 for class B-1 products)

Operating 95% relative humidity at +40 °C for 24 hours
Nonoperating 90% relative humidity at +65 °C for 24 hours

Altitude (Tested to MIL-T-28800E paragraph 4.5.5.2)

Operating to 4,500 m
Nonoperating to 15,000 m

EMI

EMI (commercial) CISPR 11 (ISM, Group 1, class A equipment)

EMI Meets the requirements in accordance with MIL-T-28800D,

CE01 Part 2 narrow band requirements up to 15 kHz

CE03 Part 4

CS01 Part 2

CS02 Part 2

CS06 Part 5 limited to 300 V

RE01 Parts 5 and 6 measured at 30.5 cm, 15 dB relaxation to 20 kHz, and exceptioned from 20 kHz to 50 kHz.

RE02 Part 2 (limited to 1 GHz) Full limits of class A1c and A1f, with option 002 installed without option 002 installed 10 dB relaxation, 14 kHz to 1 GHz

RS02 Part 2, Part I Exceptioned

RS02 Part 2, Part II Exceptioned

RS03 Part 2, limited to 1 V/meter from 14 kHz to 1 GHz (with option 001 installed) Slight trace shift from 80 MHz to 200 MHz

Vibration

Operating 15 minutes along each of the 3 major axes; 0.635 mm p-p displacement, 10 Hz to 55 Hz in one-minute cycles. Held for 10 minutes at 55 Hz (4 g at 55 Hz).

Shock

Operating 30 g, 1/2 sine, 11 ms duration, 3 shocks per axis along major axis. Total of 18 shocks.

Physical characteristics

Size (excluding handle)

Height 172 mm
Width 322 mm
Depth 317 mm

Weight 6.2 kg

Option 005 General Performance Characteristics
(HP 54602B only)

Video Standards

NTSC
PAL
PAL-M
SECAM
Generic

Video Trigger Modes

Line (number) of Field 1
Field 2
Alternate Fields

All Lines

Field 1 Defined as that field with the 3 lines of vertical sync starting at line 4. Is actually color field 1 or color field 3.

Field 2 Defined as that field with the 3 lines of vertical sync starting at the midpoint of line 3. Is actually color field 2 or color field 4.

All Fields

Option 005 Trigger System (HP 54602B only)

Internal trigger

Sensitivity Performance remains unchanged

Coupling Performance remains unchanged

Modes Performance remains unchanged

Holdoff Performance remains unchanged

TV triggering Available on channels 1 and 2 only

TV line and field 0.5 division of composite sync for stable display

External trigger

Performance remains unchanged

Vertical output

Connector Rear panel BNC (f)

Source Impedance 50Ω (nominal)

Signal source selected by internal trigger source

Amplitude approximately 90mVp-p into 50Ω for a full scale display at full bandwidth of the oscilloscope

TV Trigger output

Connector Rear panel BNC (f)

Amplitude TTL

Pulse width a function of TV trigger mode, Minimum approximately 5us in line modes to the width of a field in field modes

Delay from Vertical Output approximately 400ns.

This glossary is organized into two parts: oscilloscope and TV/video trigger terms. The TV/video trigger terms apply to the HP 54602B with Option 005 installed.

Oscilloscope Terms

Auto A trigger mode that produces a baseline display if the trigger conditions are not met. If the trigger frequency is less than 25 Hz, even if the level and slope conditions are met, a free running display will result.

Auto Level The oscilloscope sets the trigger point to the 50% amplitude point on the displayed waveform. If there is no signal present, a baseline is displayed.

Autoscale Front-panel key that automatically sets up the oscilloscope to display a signal.

Autostore displays the stored waveforms in half bright, and the most recent trace is displayed in full bright.

Baseline Free running trace on the display when no signal is applied and the trigger mode is set to auto or auto level.

BW Lim (Bandwidth Limit) Limits the displayed bandwidth of the selected channel to 20 MHz, and is available for channels 1 and 2 only. This feature is useful for viewing noisy signals

Couplng (Coupling) For the channels, it changes the input coupling. Channels 1 and 2 allow dc, ac, or ground, while channels 3 and 4 allow dc or ground. In the trigger menu, it toggles between dc and ac for trigger coupling.

Cursors Horizontal and vertical markers used for making custom voltage and time measurements.

Delay In main sweep, the delay knob moves the sweep horizontally, and indicates how far the time reference is from the trigger point. In delayed sweep the delay knob moves the starting point of the portion of the main sweep to be expanded by the delayed sweep.

Delayed Gives an expanded view of the main sweep.

Display Allows selection of either normal, peak detect, or averaged display modes.

Erase Clears the display.

External Trigger Is available only on the two channel oscilloscope. Nonviewable input that is usable as a trigger source only.

Field 1 Triggers on the field 1 portion of the video signal.

Field 2 Triggers on the field 2 portion of the video signal.

HF Reject (high frequency reject) Adds a low pass filter with a 3 dB point at 50 KHz to the trigger path.

Holdoff Keeps the trigger from rearming for an amount of time set by the holdoff knob.

Internal Trigger The oscilloscope triggers from a channel input that you choose.

Invert Invert shifts the displayed waveform 180 degree, and is available for channels 1 and 2 only. When the oscilloscope is triggered on the signal to be inverted, the trigger is also inverted.

Level Front-panel knob that changes the trigger level.

LF Reject (low frequency reject) Adds a high pass filter with a 3 dB point at 50 KHz to the trigger path.

Line In TV trigger mode, the oscilloscope triggers on the TV line sync pulses. As a trigger source, the oscilloscope triggers off of the power line frequency.

Main Sets the oscilloscope to a volts vs time display that displays the main time base sweep.

Mode Allows you to select one of five trigger modes, Auto level, Auto, Normal, Single, TV.

Noise Rej (noise reject) Decreases the trigger sensitivity to reduce the triggering on signal noise.

Normal If a trigger signal is present and the trigger conditions are met, a waveform is displayed. If there is no trigger signal, the oscilloscope does not trigger and the display is not updated.

Peak Det (peak detect) Allows detection of signal extremes as the sample rate is decreased in the 5 s to 50 ms/div time base settings.

Polarity Selects either positive or negative TV sync pulses.

Position Knob that moves the signal vertically on the display.

Print/Utility Allows access to the module menus and service menus.

Probe Allows selection of 1, 10, or 100 to match a probe's division ratio so that the vertical scaling and voltage measurements reflect the actual voltage levels at the tip of the probe.

Recall Recalls a selected front-panel setup that you saved to one of 16 memory location. Memory selection is with either a softkey or the knob closest to the Cursors front-panel key.

Recall Setup Recalls the front-panel setup that was saved with a waveform.

Run The oscilloscope acquires data and displays the most recent trace.

Save Saves the current front-panel setup to one of the possible 16 memory locations. Memory selection is with either a softkey or the knob closest to the Cursors front-panel key.

Setup Allows access to front-panel setup keys.

Single (single shot) The oscilloscope triggers once when the trigger conditions are met. The oscilloscope must be rearmed before the oscilloscope retriggers by pressing either the Run or Autostore front-panel keys.

Slope/Coupling Allows access to the trigger slope and input coupling menus.

Slope Selects either the rising or falling edge of the signal to trigger the oscilloscope.

Source Allows you to select a trigger source.

Stop Freezes the display.

Time Allows access to the automatic time measurement keys.

Time/Div Changes the time base in a 1-2-5 step sequence from 2 ns to 5 s.

Time Ref Lft Cntr (time reference left or center) Sets the time reference to either one graticule in from the left edge of the display or to center of the display.

Trace Allows access to the trace storage keys.

Trace Mem (trace memory) One of two pixel memory locations used for storing traces.

TV Allows access to the TV slope and trigger coupling keys.

Vernier Vernier allows a calibrated fine adjustment with the channel 1 and 2 Volts/Div knob, and the time base Time/Div knob.

Voltage Allows access to the automatic voltage measurement keys.

Volts/Div Changes the vertical scaling in a 1-2-5 step sequence from 2 mV to 5 V.

XY Changes the display to a volts versus volts display.

TV/Video Trigger Terms

Blanking Level The level of the composite picture signal that separates the range containing picture information from the range containing synchronizing information. (IEEE Definition)

Chrominance That property of light which produces a sensation of color in the human eye apart from any variation in luminance that may be present.

Chrominance Signal That portion of the color television signal which contains the color information. (STOC Definition)

Color Burst In color systems, this normally refers to a burst of subcarrier frequency (8 to 10 cycles of 3.579545 MHz in NTSC systems) on the back porch of the composite video signal used to establish a frequency and phase reference for the chrominance signal.

Composite Sync The line and field rate synchronizing pulses (including the field equalizing pulses), when combined together, form the composite sync signal.

Composite Video For color, this consists of blanking, field, and line synchronizing signals, color synchronizing signals, plus chrominance and luminance picture information. These are all combined to form the complete color video signal.

Equalizing Pulses Pulses of one half the width of the horizontal sync pulses which are transmitted at twice the rate of the horizontal sync pulses during the portions of the vertical blanking interval immediately preceding and following the vertical sync pulse. These pulses cause the vertical deflection to start at the same time in each interval. They also keep the horizontal sweep circuits in step during the portions of the vertical blanking interval immediately preceding and following the vertical sync pulse.

Field One of the two (or more) equal parts of information into which a frame is divided in interlace scanning; alternately, one half of a complete picture (or frame) interval, containing all of the odd, or all of the even, lines of the picture.

Field 1 Triggers on the field 1 portion of the video signal.

Field 2 Triggers on the field 2 portion of the video signal.

Frame One complete picture consisting of two fields of interlaced scanning lines.

HF Reject (high frequency reject) Adds a low pass filter with a 3 dB point at 50 KHz to the trigger path.

Holdoff Keeps the trigger from rearming for an amount of time set by the holdoff knob.

Internal Trigger The oscilloscope triggers from a channel input that you choose.

Invert Invert shifts the displayed waveform 180 degree, and is available for channels 1 and 2 only. When the oscilloscope is triggered on the signal to be inverted, the trigger is also inverted.

IRE An abbreviation for Institute of Radio Engineers.

IRE Scale An oscilloscope scale that applies to composite video levels. There are 140 IRE units in one volt.

Line In TV trigger mode, the oscilloscope triggers on the TV line sync pulses. As a trigger source, the oscilloscope triggers off of the power line frequency.

Luminance The amount of light intensity, which is perceived by the eye as brightness (referred to as "Y")

Main Sets the oscilloscope to a volts vs time display that displays the main time base sweep.

Mode Allows you to select one of five trigger modes, Auto level, Auto, Normal, Single, TV.

Noise Rej (noise reject) Decreases the trigger sensitivity to reduce the triggering on signal noise.

NTSC National Television Systems Committee. An industry-wide engineering group which, during 1950-1953, developed the color television specifications now established in the United States, Canada, Japan, and Mexico. A 525 line, 60 Hz field, 4.2 MHz system. Two frames (4 fields) for picture completion.

PAL Phase Alternating Line or Phase Alteration Line rate. Color television standards used in Europe. A 625 line, 50 Hz field system. Eight fields for picture completion.

PAL-M Phase Alternating Line or Phase Alteration Line rate. A version of the European system adapted to a 525 line, 60 Hz field, 4.2 MHz bandwidth used in Brazil.

SECAM SEquentiel Couleur Avec Memoire. An acronym derived from the French phrase meaning Sequential Color with Memory. Color television specifications used primarily in France and the former Soviet Union. A 625 line, 50 Hz field, wide bandwidth system. Two frames (4 fields) required for picture completion

Sync An abbreviation for the words "synchronization," "synchronizing," etc. Applies to the synchronization signals, or timing pulses, which lock the electron beam of the picture monitors in step, both horizontally and vertically, with the electron beam of the pickup tube. The color sync signal (NTSC) is known as the color burst.

Vertical Blanking Interval The blanking portion at the beginning of each field. It contains the equalizing pulses, the vertical sync pulses, and VITS (if desired). Presently 18 to 21 lines in duration.

Vertical Interval Reference (VIR) A signal used as a reference for amplitude and phase characteristics of a color television program (FCC assigned to line 19).

Vertical Interval Test Signal A signal which may be included during the vertical blanking interval to permit in-service testing and adjustment of video transmission.

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DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company

Manufacturer's Address: Colorado Springs Division
1900 Garden of the Gods Road
Colorado Springs, CO 80907 USA

declares, that the product

Product Name: Digitizing Oscilloscope

Model Number(s): HP 54600B, HP 54601B, HP 54602B, and HP 54603B

Product Option(s): All

conforms to the following Product Specifications:

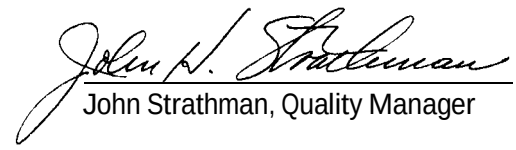
Safety:	IEC 1010-1:1990+A1 / EN 61010-1:1993	
	UL 3111	
	CSA-C22.2 No. 1010.1:1993	
EMC:	CISPR 11:1990 / EN 55011:1991	Group 1 Class A
	IEC 555-2:1982 + A1:1985 / EN 60555-2:1987	
	IEC 555-3:1982 + A1:1990 / EN 60555-3:1987 + A1:1991	
	IEC 801-2:1991 / EN 50082-1:1992	4 kV CD, 8 kV AD
	IEC 801-3:1984 / EN 50082-1:1992	3 V/m, {1kHz 80% AM, 27-1000 MHz}
	IEC 801-4:1988 / EN 50082-1:1992	0.5 kV Sig. Lines, 1 kV Power Lines

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE marking accordingly.

This product was tested in a typical configuration with Hewlett-Packard test systems.

Colorado Springs, 01/23/97



John Strathman, Quality Manager

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Product Regulations

Safety

IEC 1010-1:1990+A1 / EN 61010-1:1993
UL 3111
CSA-C22.2 No.1010.1:1993

EMC

CE
ISM 1-A

N279

This Product meets the requirement of the European Communities (EC) EMC Directive 89/336/EEC.

Emissions EN55011/CISPR 11 (ISM, Group 1, Class A equipment)

Immunity

EN50082-1	Code[1]	Notes[2]
IEC 555-2	1	
IEC 555-3	1	
IEC 801-2 (ESD) 4kV CD, 8kV AD	2	
IEC 801-3 (Rad.) 3 V/m	2	
IEC 801-4 (EFT) 0.5 kV, 1kV	1	

[1] Performance Codes:
1 PASS - Normal operation, no effect.
2 PASS - Temporary degradation, self recoverable.
3 PASS - Temporary degradation, operator intervention required.
4 FAIL - Not recoverable, component damage.

[2] Notes: (none)

Sound Pressure Level Less than 60 dBA

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Hewlett-packard Company

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Document Warranty

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Safety

This apparatus has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warning

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock or fire hazard.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- If you energize this instrument by an auto transformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Use caution when exposing or handling the CRT. Handling or replacing the CRT shall be done only by qualified maintenance personnel.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

Hazardous voltage symbol.

Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

WARNING

The Warning sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a Warning sign until the indicated conditions are fully understood and met.

CAUTION

The Caution sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a Caution symbol until the indicated conditions are fully understood or met.

Hewlett-Packard
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1900 Garden of the Gods Road
Colorado Springs, CO 80901

Product Warranty

This Hewlett-Packard product has a warranty against defects in material and workmanship for a period of three years from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products that prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by Hewlett-Packard.

For products returned to Hewlett-Packard for warranty service, the Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country.

Hewlett-Packard warrants that its software and firmware designated by Hewlett-Packard for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument software, or firmware will be uninterrupted or error free.

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The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

No other warranty is expressed or implied. Hewlett-Packard specifically disclaims the implied warranties of merchantability or fitness for a particular purpose.

Exclusive Remedies

The remedies provided herein are the buyer's sole and exclusive remedies. Hewlett-Packard shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales Office.

Certification

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

About this edition

This is the *HP 54600B, HP54601B, HP 54602B, and HP 54603B Oscilloscopes User and Service Guide*.

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New editions are complete revisions of the manual. Many product updates do not require manual changes; and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.